GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: 8/29/80

Project Title: Solar Energy Meteorological Research and Training Site

Project No: E-16-C03 (Subprojects are E-21-C03/Schlag, B-495-003/Sales, G-35-C03/Metcalf)

Project Director: Dr. C. G. Justus

Sponsor: Department of Energy

Agreement Period: From 7/1/80 Until 9/30/81 (04 year only)

Type Agreement: Grant No. DE-FG05-77ET20153 (formerly Grant No. EG-77-G-05-5604) Mod. A003
$2000,000 (partially funded at $100,000)

Amount:

	AE		EE		ERL	
DOE	$43,884	(E-16-C03)	$16,266	(E-21-C03)	$12,111	(B-495-003)
GIT	1,642	(E-16-345)	582	(E-21-354)	447	(E-132-101)
	$45,526		$16,848		$12,558	

Reports Required: Letter type summary activity report

Sponsor Contact Person (s):

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Contract Management Branch
Procurement & Contracts Division
US DOE-Oak Ridge Operations
P. O. Box E
Oak Ridge, TN 37830
(615)576-0794

Continuation of E-16-C02

Defense Priority Rating: N/A

Assigned to: Aerospace Engineering (School)

COPIES TO:

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- Project Code (GTRI)
- Other C. E. Smith

GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date October 28, 1983

Project No. E-16-C03 School/~~Lab~~ Aerospace Eng.

Includes Subproject No.(s) E-21-C03, G-35-C03, B-495

Project Director(s) Dr. C. G. Justus GTRI/~~GIT~~

Sponsor Department of Energy

Title: Solar Energy Meteorological Research and Training Site

Effective Completion Date: 9/30/81 (Performance) (Reports)

Grant/Contract Closeout Actions Remaining

- [x] None
- [ ] Final Invoice or Final Fiscal Report
- [ ] Closing Documents
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other

Continues Project No. E-16-C02

Continued by Project No. E-16-C04

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Other

Form OCA 58:1004

E16-C03

ORO/5604-81-1

PROGRAM FOR SOLAR ENERGY METEOROLOGICAL RESEARCH AND TRAINING SITE (REGION 3)

Quarterly Technical Status and
Contract Management Report

C. G. Justus, Principal Investigator

Georgia Institute of Technology
Atlanta, GA 30332

Report Period October 1, 1980 - December 31, 1980

PREPARED FOR THE UNITED STATES
DEPARTMENT OF ENERGY

DIVISION OF DISTRIBUTED SOLAR TECHNOLOGY

UNDER GRANT DEFG05-77-ET20153

Georgia Tech Project E-16-C03

1. PROJECT OBJECTIVES

This broad program of solar energy and meteorological monitoring, training, and research has the following main objectives for the proposed 5 years duration:

(1) to provide for the Southeast Region (Region 3) a set of continuously monitored and quality controlled data on solar radiation and atmospheric phenomena related to solar energy collection, conversion, and storage, and to relate these to the extensive ongoing solar energy research and engineering projects carried out by Georgia Tech and in the Southeast Region.

(2) by analysis of monitoring results at two sites (on campus, adjacent to the Georgia Tech thermal Test facility and off-campus adjacent to the Shenandoah Solar Total Energy Site), determine: a) optimum siting of solar radiation and meteorological monitoring instruments relative to solar energy systems to provide the most representative site data with the least influence from the solar collector systems, b) adequacy and representativeness for the Southeast Region of various methodologies for relating easily measured phenomena (minutes of sunshine, cloud cover, etc.) to engineering quality solar radiation data (direct, diffuse, and global insolation, etc.).

(3) to establish and maintain a training program which will allow: a) undergraduate and graduate engineering students, through elective or minor courses, to become informed in the areas of meteorology and atmospheric science as they relate to solar and wind energy, b) graduate students in the atmospheric sciences to become informed of the specific requirements of monitoring, analysis, interpretation and presentation of meteorological information related to engineering aspects of solar and wind

energy, c) professionals in various fields, through short courses and seminars, to become familiar with the new and rapidly developing aspects of solar energy engineering and technology, especially the radiation monitoring and meteorological aspects of this field.

(4) through cooperation in the 3/2 dual degree program, the National Consortium for Graduate Degrees for Minorities in Engineering and other academic programs, enhance the opportunities for minorities (especially Black American and Puerto Ricans) and women in the solar energy engineering and technology field.

(5) instrumentation and monitoring techniques research and development to enhance the engineering applicability of the solar radiation and meteorological monitoring and to provide better instructional tools through low cost instrument systems for educational purposes.

(6) to investigate, with the fixed site instruments and the portable monitoring units (PMU's), the influence of urban haze and aerosols as well as the high levels of natural turbidity which occur in parts of the Southeast region, and with the PMU's to sample the effects on solar radiation of a wide variety of geography (which spans coastal, piedmont plains, and mountainous within the Southeast region).

2. PROJECT PLAN

A. Research Approach and Definition of Tasks

The proposed project plan is divided into three major tasks, each with several subtasks, as follows:

Task 1: Solar Radiation and Meteorological Monitoring Program

This task includes acquisition, initial calibration, and installation of the solar radiation and meteorological instrumentation at the on-campus (Solar Thermal Test Facility/Wind Turbine Test Facility) site and the off-campus (Shenandoah Georgia Solar Total Energy Project) site. Existing and new instrumentation at these sites will be combined and interfaced through data loggers and magnetic tape recording into a form which can be processed, summarized, and formatted by the main campus computer (CYBER 70/74 system). Annual calibration of the instrumentation, against national standards where appropriate, will be carried out, as well as more frequent field calibration of the radiation monitoring instruments. A carefully monitored program of daily instrument inspection and routine maintenance will also be carried out. The detailed outline of the various subtasks under Task 1 is as follows:

a. Based on the proposed variables to be monitored, the Instrumentation Network Design will be laid out using equipment assigned by Georgia Tech for use on this program and additional units to be purchased with the sponsor's approval.

b. Using the preliminary network design, the Selection, Order, and Delivery will be based on recommendations made at the preliminary review meeting of all of the principal investigators.

c. Before an instrument or support unit is put into service, each piece of equipment will be examined and subjected to an Instrument Check and Certification for conformation to Georgia Tech and vendor specifications.

Instruments which fail to pass inspection will be returned to the vendor for replacement.

d. The design, fabrication, and installation of the Auxiliary Hardware which will house and/or support the instrumentation will be according to recommendations in the above articles, of the respective vendors, and to experience gained through use of similar apparatus.

e. Campus Site Modification and Preparation will be done as necessary to accomodate the new monitoring site and instrumentation.

f. The Relocation of Existing Instruments will be performed expeditiously to prevent a loss of data in the present continuous monitoring system. Exposure and operation of the solar radiation and meteorological monitoring instruments will be in accordance with criteria and guidelines published by the WMO(1971) and the IGY (1958).

g. The Instrumentation will be installed and calibrated after it is received and certified.

h. Campus Site Monitoring for the total system is scheduled to begin during the last month of Year 1, but a continuous monitoring system will have been in use for the entire period.

i. The Shenandoah Monitoring System will be used for the entire period after the "Sandia Solar Monitor System" is installed. This basic instrument package will be augmented by additional equipment. Data from the Shenandoah System will be logged on cassette tape. It will then be reformatted and merged with the campus site monitoring data on the CYBER system and put on magnetic tape.

j. Analytical Software will be developed in a standard format which will be used for all research sites. This format was selected at the project directors meeting in Washington, D. C. Data will be taken for analysis

to the CYBER 70/74 computer for transfer to the standard format and storage in this format on magnetic tape, and for transmittal of the raw and summarized data to the National Climatic Center in Asheville.

k. An Instrumentation Calibration by use of a set of special instruments or by techniques specified by the instrument vendor will be performed quarterly to verify instrument accuracy and to establish a permanent record of possible instrument degradation which would affect the acquired data.

l. At the end of each phase of the program, the set of standards would be taken to the Solar Radiation Calibration Facility in Denver, Colorado for Certification of Standard Instruments.

m. The Data Transfer to the National Climatic Center is scheduled to begin on a monthly basis at the end of Year 1 and would continue for the next 48 months. The data will also be stored at Georgia Tech.

Task 2: Solar Energy/Meteorology Training Program

This task involves development and implementation of on-campus, immediate area, and regional training. Existing graduate courses in general meteorology and boundary layer meteorology will be expanded by a new graduate course (open to seniors) in the area of meteorology for solar and wind energy. This course will include training in instrumentation, data acquisition, reduction and analysis. With the formation of an Atmospheric Sciences academic program anticipated to begin in September 1978, this academic curriculum will offer engineers and engineering technologists the opportunity to learn, as a minor or elective course basis, fundamentals of meteorology as it applies to solar energy engineering and technology. It will also allow meteorologists and atmospheric science students in the new program to interact with and learn about the engi-

neering problems and needs related to solar energy technology. This academic program and related short courses for professionals will be made available as appropriate through a unique instructional TV system to become operational at Georgia Tech in September 1978. A "traveling course" to be put on as a short course or a one quarter course at regional colleges will also be implemented. Initially this will be conducted by Georgia Tech personnel. Later, as arrangements are worked out and the local college has personnel trained to proctor or tutor the course, this will be carried via the TV system, either on a video cassette delivery basis, or if the system is developed, via a satellite TV link.

Task 3: Instrumentation and Monitoring Techniques Research

Various research and development aspects related both to the monitoring and the training program, will be carried out under this task. The location of the two monitoring sites - one on-campus within about two miles from the heart of downtown Atlanta, one at the new town Shenandoah site, about 45 miles from Atlanta - will allow evaluation of urban/rural differences, especially related to urban haze and aerosols. The exposure of the instruments adjacent to the Solar Thermal Test Facility and Wind Turbine Test Facility at Georgia Tech will allow evaluation of potential effects on temperature, moisture, and air flow near such facilities. Hence optimum locations will be evaluated for instruments near solar energy facilities, to provide maximum degree of representativeness and minimum influence from the solar energy system on the meteorological measurements. Many models have been proposed in which various meteorological and simply measured radiation parameters (sunshine hours, temperature, cloud cover, solar declination, etc.) can be used to estimate engineering quality insolation (global and direct insolation, global on inclined surfaces, etc.). Some of these methods are those of Fritz (1957), Angstrom (1956), Black et al (1954), Glover and McCulloch (1958), Sabbagh et al (1977), Liu and Jordan (1960),

Whillier (1956) Bennett (1965), Swartman and Ogunladeo (1967), Reddy (1971a, 1971b), Norris (1966), Masson (1966), Atwater (1974), Lumb (1964), L'Vova (1972), Machta (1974), Paltridge (1974), Lin (1973), and Randall et al (1977). Through NOAA (Machta, private communication) a set of linear regression coefficients is being developed for the 26 rehabilitated solar radiation data stations. Using this model, the National Climatic Center will prepare, by November 1977, solar radiation estimates for 200 stations in the U.S. These data will be put on magnetic tape in SOLMET format. The data from the on-campus and off-campus monitoring sites as well as from the 5 Southeastern sites in the new 35 site NOAA network (Riches, 1975) will be used to study regional relationships between simply monitored parameters and solar radiation data for engineering purposes. Results of the contract study resulting from the recent RFP to Perform a Solar Radiation Data Forecast and Interpolation Analysis will also be applied in this study. Emphasis will be on study of the influence of turbidity (high in parts of the Southeast region), and regional geography (which spans coastal, piedmont plains, and mountain areas). During the second and subsequent years up to three low cost portable monitoring units will be designed and built. These units will be used in the training program as instructional systems for the traveling course to regional colleges. Data from these units will also be used in the analysis of methods to relate simple measured parameters to engineering quality insolation data for the region. Other instrument and monitoring techniques for which research and development projects are envisioned will include:

a. an automatic filter changing wheel for the normal incidence pyrheliometer (to automatically switch on a 1/minute or less basis between clear, OG1, RG2, and RG8 filters),
b. circumsolar radiation with the Lawrence Berkley Labs circumsolar telescope, currently on campus and projected to remain here throughout at least a portion of this project, and

c. an automatic wide field of view camera system to provide a film record of cloud cover conditions.

3. ADMINISTRATIVE STATUS

No administrative changes have been made. The project team and organization is now as shown in Figure 3.1.

4. PROGRESS TO DATE

Task 1: Solar Radiation and Meteorological Monitoring Program

a. Completed in prior period. No modifications required.

b. Completed in prior period. No modifications required.

c. Completed in prior period.

d. Completed in prior period.

e. Completed in prior period. Campus site now in full operation.

f. Completed in prior period.

g. During the prior quarter, the traveling standard CSIRO total radiometer was received and compared to Georgia Tech and Shenandoah total radiometers. Some results were reported at the Davis review meeting. Word on whether large differences ($\sim$10%) in short-wave and long-wave calibrations are real is still being awaited from Trinity University.

h. Campus-site monitoring continues. Except for the usual maintenance, all instrumentation functioned properly throughout the quarter.

i. The Shenandoah monitoring system continues in operation. Data reduction and quality control is current.

j. Completed in prior period. Routine daily spot checks continue for the serial output from the on-campus site.

k. See item g, above.

l. A PSP calibration was done at NOAA in September 1980. Further comparisons and sun-shade checks against the Kendall active cavity radiometer will be done in the next calibration tests.

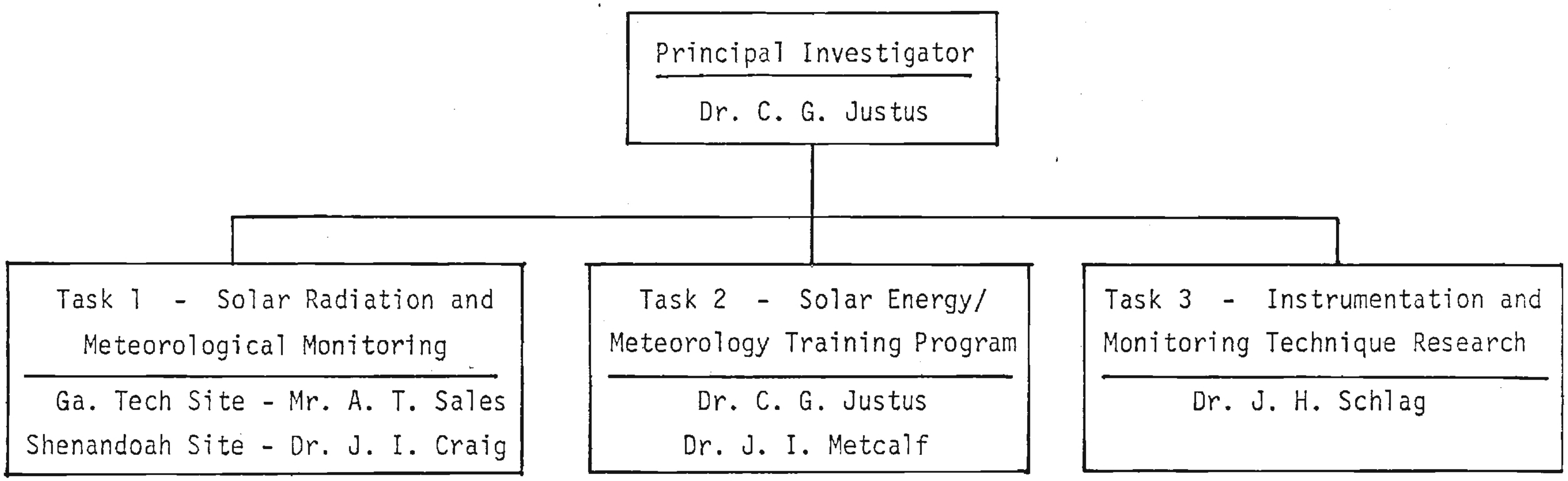


Figure 3.1 - Project Organization Chart

m. Transfer of one year of on-campus data and Shenandoah data to NCC is complete. Further data will be transferred as it is processed.

Task 2: Solar Energy/Meteorological Training Program

A workshop for NOAA personnel, regional, and state energy office people and state climatologists within the region was conducted in September. The program concentrated on energy and climate applications of solar radiation.

The NSF minority graduate training program "Graduate Research Opportunities in Atmospheric and Terrestrial Sciences" has been funded. A site visit by our Mobile Atmospheric Research Vehicle (MARV) and newly acquired tethered balloon, system is planned at Jackson State University, a minority college in Jackson, Mississippi, during next quarter.

Task 3: Instrumentation and Monitoring Techniques Research

Because of continuing problems with the MARS data logger, the portable trailer system is being discontinued. Instead a combination of instruments will be mounted in the MARV unit. Mounting of these instruments in the MARV van is underway.

The all-sky camera system continues to operate well. A visiting faculty member from Jamaica, assisted by a student are continuing quantitative analyses of these data.

The photocell direct beam radiometer continues to undergo field tests. It still appears to compare quite closely with NIP readings (generally $\lesssim$5% error). The automated sun photometer is in operation, after the μA current amplifier to yield suitable voltage level output signals has been constructed.

Comparisons of the Campbell-Stokes sunshine duration data with NIP-derived percent sunshine continue. A fairly large scatter in a regression type relationship is typical under partly cloudy conditions, especially at near-sunrise or near-sunset periods. Some of these results were reported in the annual report and will be presented at the Georgia Academy of Science in April 1981 meeting.

Operation of the Lawrence Berkely labs circumsolar telescope on the Georgia Tech campus has now shifted from the personnel of the Advanced Components Test Facility to personnel directly working on this projects. Some instrumentation problems with this unit persist, however. Attached tables give monthly summaries of solar radiation measurements at Georgia Tech for April-July 1980. April 1979 - March 1980 summaries were given in the annual report. The period of 4 days of missing day in June 1980 and 2 days of missing data in July 1980 and due to overheating in the instrument recording shelter, during the record-breaking heat-wave period, with resultant damage to some of the recording tape as data were being recorded on the data logger.

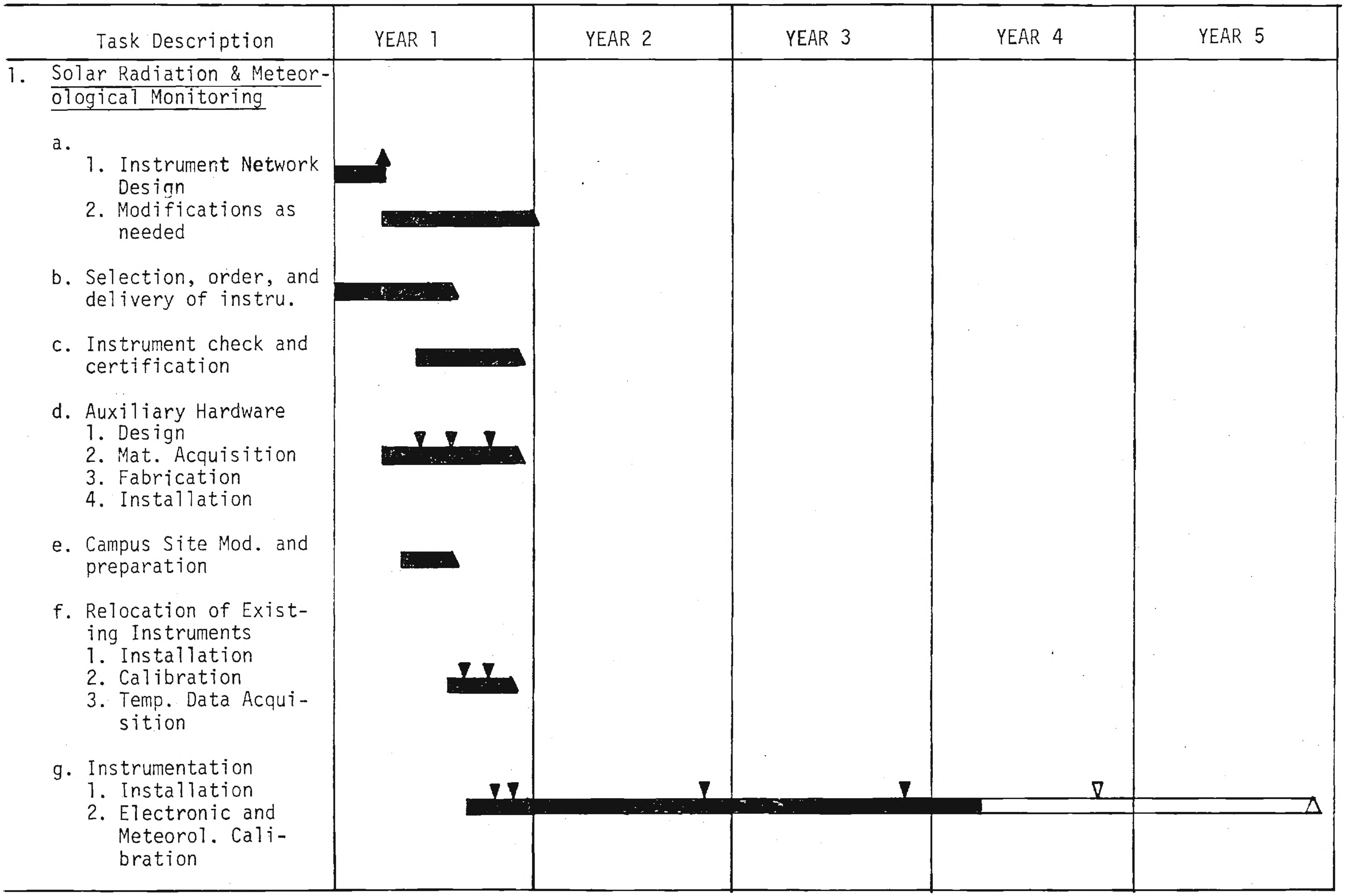
Urban/rural comparisons between Georgia Tech and Shenandoah continue. Intersite differences during a three week study at St. Croix, U.S. Virgin Islands West Indies Laboratory indicate consistent inter-site differences in that tropical regime as those found on the mainland U.S. These results will also be reported at the April 1981 Georgia Academy of Sciences, by the student who conducted the St. Croix tests.

MILESTONES AND BUDGET

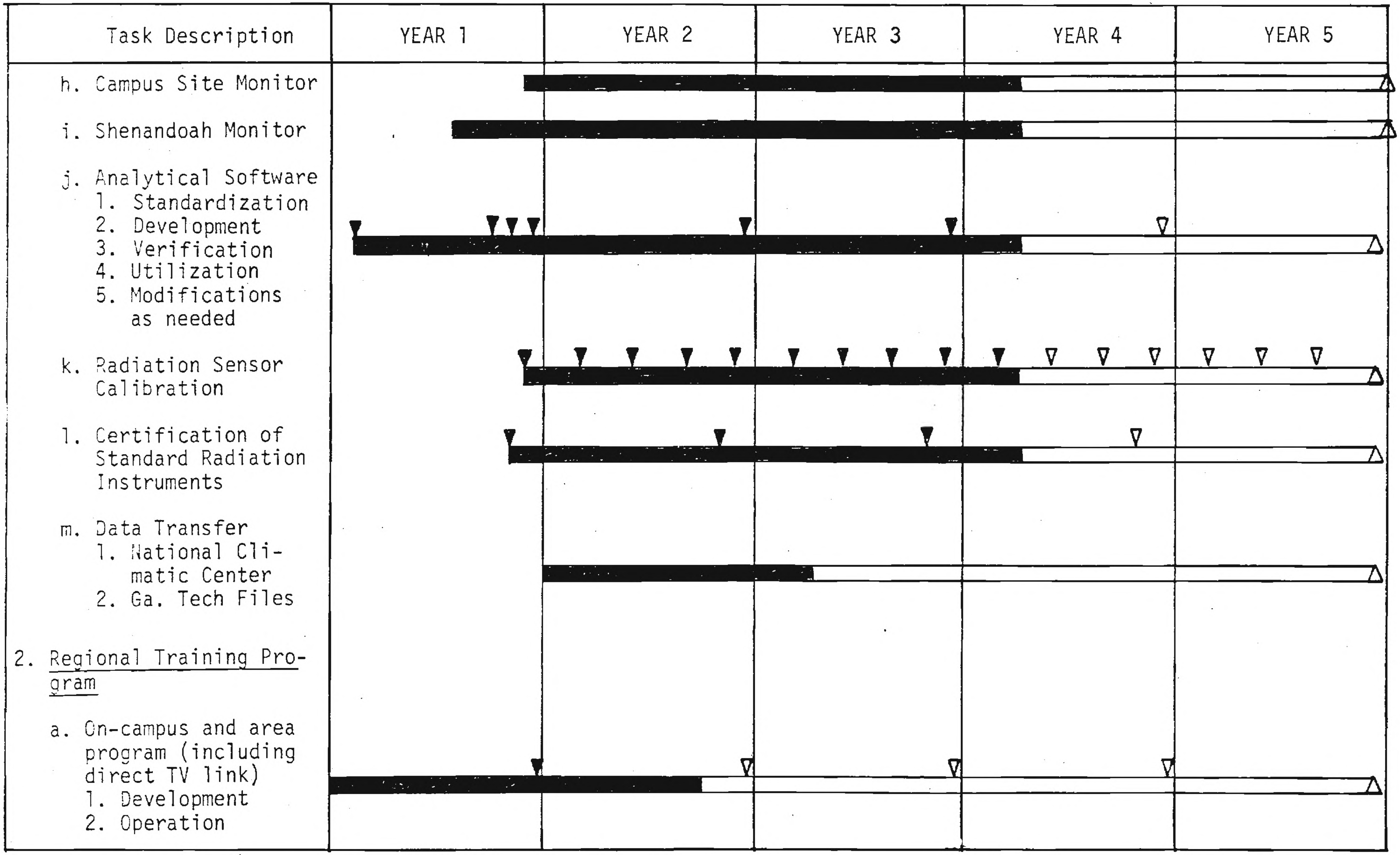
Expenditures in the current project year, through December 1980, total approximately $50,000, which is just on the linear projection project expenditure plan.

A detailed milestone and progress chart is attached.

Milestone Chart



Milestone Chart (Cont'd.)



Milestone Chart (Cont'd)

Task Description	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
b. Southeast Region Training Program 1. Develop regional arrangements 2. In-person traveling regional courses 3. Regional TV training courses					
3. <u>Instrument and Monitoring Technical Research</u>					
a. Solar Energy Site Influence					
b. Urban/Rural Comparisons					
c. Analysis of Regional Relations					
d. Portable Monitoring Units (PMU) for Training and Regional Study 1. Design (PMU's) 2. Instrument acquisition 3. Construction and testing 4. Cycle of field operation and training courses		Unit 1	Unit 2	Unit 3	
e. On-campus operation of the LBL Circumsolar Telescope					

Milestone Chart (cont'd)

Task Description	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
f. Automatic sun photometer					
1. Research and development 2. Testing and operation		▽	▽		△
g. Automatic cloud cover camera 1. Research and development 2. Testing and operation		▼	▼		△
4. <u>Reports and Review Meetings</u>					
Technical Status Reports	▼ ▼ ▼	▼ ▼ ▼	▼ ▼ ▼	▼ ▽ ▽	▽ ▽ ▽
Review Meeting	▼ ▼	▼ ▼	▼ ▼	▼ ▽	▽ ▽
Technical Progress Reports	▼	▼	▼	▽	▽

ATLANTA (GA TECH) YEAR 1980 MONTH 4

DIRECT NORMAL KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	HOUR 13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
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3	0	0	0	0	0	0	2	3	3	3	3	3	41	43	265	30	3	3	3	0	0	0	0	0	405.	24
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5	0	0	0	0	0	0	483	2126	2860	3207	3398	3481	3535	3528	3452	3298	3030	2470	1176	0	0	0	0	0	36044.	24
6	0	0	0	0	0	0	563%	1689	2771	3099	3272	3243	1186	1879	2002	3055	2753	2129	1064$	0	0	0	0	0	28706.	24
7	0	0	0	0	0	0	9999*	9999*	30*	39	5	3	3	3	183	13	372	72	3	0	0	0	0	0	99999.	*21
8	0	0	0	0	0	0	2	3	3	4	3	3	36	1215	1928	609	9	87	98	0	0	0	0	0	3999.	24
9	0	0	0	0	0	0	751%	2392	2976	3213	3133	3291	2928	3233	3154	2997	2978	2393	1090	1	0	0	0	0	34529.	24
10	0	0	0	0	0	0	702	2288	2905	3212	3386	3433	3445	3440	3338	3211	2932	2379	1068	1	0	0	0	0	35740.	24
11	0	0	0	0	0	0	565	1936	2575	2989	3233	3290	3218	2299	1897	121	4	4	4	0	0	0	0	0	22137.	24
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22	0	0	0	0	0	0	1033$	2066	2720	3016	3084*	9999*	9999*	3129*	3086	3024	2759	2236	1044	6	0	0	0	0	99999.	*20
23	0	0	0	0	0	0	538	1691	2298	2620	2817	2925	3019	3020	2869	1688	1490	1266	308	2	0	0	0	0	26552.	24
24	0	0	0	0	0	0	543	1442	2148	2289	2313	1022	1070	1713	2048	1477	1773	1704	718	5	0	0	0	0	20267.	24
25	0	0	0	0	0	0	478	1390	1963	2309	2495	1734	987	1512	599	1438	970	592	73	1	0	0	0	0	16539.	24
26	0	0	0	0	0	2%	3	3	3	3	3	7	84	259	76	3	3	3	46	10	0	0	0	0	505.	24
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AV	0	0	0	0	0	0$	358$	1068$	1530$	1772	1874$	1841$	1669$	1656$	1587	1369	1234	955	396	2	0	0	0	0	17311.$	
HR	30	30	30	30	30	29	28	29	29	30	29	29	29	29	30	30	30	30	30	30	30	30	30	30		711

FLAGS:

% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS

* - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS

$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 4

DIRECT (RG630) KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
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2	0	0	0	0	0	0	51	21	6	17	14	27	6	8	15	7	6	6	6	0	0	0	0	0	192.	24
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5	0	0	0	0	0	0	424	1563	1913	2052	2130	2163	2189	2190	2164	2112	2009	1773	986	0	0	0	0	0	23669.	24
6	0	0	0	0	0	0	474	1235	1875	1993	2057	2014	707	1157	1262	1961	1844	1558	779$	0	0	0	0	0	18919.	24
7	0	0	0	0	0	0	9999*	9999*	22*	27	7	6	6	6	116	13	271	59	7	0	0	0	0	0	99999.	*21
8	0	0	0	0	0	0	5	7	6	7	7	7	18	655	1123	362	10	63	90	0	0	0	0	0	2360.	24
9	0	0	0	0	0	0	647	1744	1987	2063	1974	2066	1821	2019	1989	1917	1966	1691	903	2	0	0	0	0	22790.	24
10	0	0	0	0	0	0	602	1661	1934	2056	2125	2139	2129	2133	2106	2047	1930	1675	885	2	0	0	0	0	23424.	24
11	0	0	0	0	0	0	483	1420	1764	1943	2046	2054	1994	1427	1196	92	8	8	8	1	0	0	0	0	14443.	24
12	0	0	0	0	0	0	5	6	6	6	6	6	6	6	6	6	6	6	6	1	0	0	0	0	80.	24
13	0	0	0	0	0	0	5	9	12	6	6	6	6	7	7$	6	6	6	6	1	0	0	0	0	91.	24
14	0	0	0	0	0	0	7	7$	7	141	6	33	72	89	7	126	28	6	6	1	0	0	0	0	535.	24
15	0	0	0	0	0	0	562	1542	1749	2086	2185	2155	1978	1762	1742	1130	649	772	300	3	0	0	0	0	18615.	24
16	0	0	0	0	0	0	547	1521	1947	2071	2164	2217	2232	2210	2191	2149	2007	1729	891	2	0	0	0	0	23877.	24
17	0	0	0	0	0	0	61	742	1797	1780	1930	1975	1472	1309	908	431	408	1113	623	2	0	0	0	0	14550.	24
18	0	0	0	0	0	0	6	6	6	29	349	560	677	355	225	222	643	243	136	2	0	0	0	0	3459.	24
19	0	0	0	0	0	0	6	6	6	6	688	1449	1866	1446	1911	1232	1301	1246	563	2	0	0	0	0	11727.	24
20	0	0	0	0	0	0	435	1136	1580	1719	1859	1891	1860	1201	361	714	413	933	253	3	0	0	0	0	14360.	24
21	0	0	0	0	0	0	538$	1075	1362	1766	1787	1252	1572	1577	1748	1791	1265	840	521	4	0	0	0	0	17098.	24
22	0	0	0	0	0	0	774$	1548	1859	1978	2000*	9999*	9999*	2005*	1997	1971	1849	1598	863	8	0	0	0	0	99999.	*20
23	0	0	0	0	0	0	469	1271	1580	1727	1813	1867	1902	1892	1825	1092	1013	910	265	4	0	0	0	0	17632.	24
24	0	0	0	0	0	0	472	1083	1514	1553	1558	687	701	1127	1371	1008	1254	1281	621	8	0	0	0	0	14238.	24
25	0	0	0	0	0	1	422	1077	1384	1550	1630	1125	648	995	431	1070	747	504	73	2	0	0	0	0	11659.	24
26	0	0	0	0	0	1	6	6	6	6	6	8	45	147	46	6	6	6	43	11	0	0	0	0	349.	24
27	0	0	0	0	0	2	668	558	280	527	943	395	430	503	321	212	108	6	6	2	0	0	0	0	4960.	24
28	0	0	0	0	0	9999*	616*	1187	1685	1718	1240	658	952	754	524	953	866	60	167	2	0	0	0	0	11058.	$22
29	0	0	0	0	0	1	64	6	702	1363	1222	1138	52	7	427	100	576	213	96	2	0	0	0	0	5968.	24
30	0	0	0	0	0	2	594	1361	1668	1803	1859	1942	1070	1191	260	251	580	6	6	2	0	0	0	0	12596.	24
AV	0	0	0	0	0	0$	309$	809$	1058$	1169	1210$	1176$	1064$	1055$	1025	906.	853	711	339	2	0	0	0	0	11686.$	
HR	30	30	30	30	30	29	28	29	29	30	29	29	29	29	30	30	30	30	30	30	30	30	30	30		711

FLAGS:
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OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 4

GLOBAL HORIZ. KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	0	31	549	1349	2111	2753	3196	3354	3246	2922	2371	1638	781	110	0	0	0	0	0	24411.	24
2	0	0	0	0	0	0	51	334	491	904	1091	1452	1291	1250	1099	734	474	308	65	0	0	0	0	0	9545.	24
3	0	0	0	0	0	0	3	134	346	437	468	1180	1432	1339	1624	841	383	151	19	0	0	0	0	0	8358.	24
4	0	0	0	0	0	0	41	338	755	1994	2624	3225	3483	3410	3071	2525	1775	925	189	0	0	0	0	0	24355.	24
5	0	0	0	0	0	0	58	630	1466	2234	2879	3295	3496	3414	3082	2515	1790	941	201	0	0	0	0	0	26001.	24
6	0	0	0	0	0	0	63	547	1418	2184	2809	3216	2704	2885	2378	2428	1720	896	448$	0	0	0	0	0	23696.	24
7	0	0	0	0	0	0	9999*	9999*	657*	1171	1040	830	1161	659	1611	986	938	384	44	0	0	0	0	0	99999.*	21
8	0	0	0	0	0	0	7	48	288	724	483	177	378	2682	2665	1297	571	436	93	0	0	0	0	0	9849.	24
9	0	0	0	0	0	0	84	706	1523	2320	2881	3342	3363	3359	3022	2424	1796	960	217	0	0	0	0	0	25997.	24
10	0	0	0	0	0	0	87	701	1517	2261	2905	3314	3492	3419	3075	2525	1799	964	212	0	0	0	0	0	26273.	24
11	0	0	0	0	0	0	99	657	1396	2173	2830	3232	3380	3147	2588	1242	578	239	24	1	0	0	0	0	21584.	24
12	0	0	0	0	0	0	3	6	28	155	162	161	236	632	587	424	422	391	51	0	0	0	0	0	3260.	24
13	0	0	0	0	0	0	38	234	539	226	437	203	332	158	99$	40	6	4	4	1	0	0	0	0	2320.	24
14	0	0	0	0	0	0	29	171$	313	746	762	910	1512	1347	815	932	627	274	39	1	0	0	0	0	8479.	24
15	0	0	0	0	0	0	112	732	1516	2352	2992	3430	3465	3433	3074	2080	1210	770	183	1	0	0	0	0	25349.	24
16	0	0	0	0	0	0	125	762	1618	2356	3000	3416	3592	3491	3169	2620	1888	1037	258	1	0	0	0	0	27333.	24
17	0	0	0	0	0	0	100	631	1669	2307	2944	3442	3214	3130	2431	1726	1237	983	225	1	0	0	0	0	24038.	24
18	0	0	0	0	0	0	45	245	810	1153	1710	2196	2722	1992	1956	1583	1455	644	144	1	0	0	0	0	16656.	24
19	0	0	0	0	0	0	30	135	328	631	2529	2923	3423	2877	3099	2050	1627	901	244	1	0	0	0	0	20798.	24
20	0	0	0	0	0	0	129	747	1493	2226	2833	3204	3362	2568	1530	1586	897	1032	164	1	0	0	0	0	21771.	24
21	0	0	0	0	0	0	381$	761	1462	2243	2806	3029	3304	3177	3060	2485	1512	726	222	1	0	0	0	0	25171.	24
22	0	0	0	0	0	0	404$	807	1596	2306	2697*	9999*	9999*	3298*	3028	2516	1800	987	254	1	0	0	0	0	99999.*	20
23	0	0	0	0	0	0	147	776	1539	2244	2855	3236	3441	3387	3016	2042	1666	898	166%	1	0	0	0	0	25416.	24
24	0	0	0	0	0	0	204	753	1518	2188	2775	2219	2567	2756	2704	1957	1614	942	247	1	0	0	0	0	22444.	24
25	0	0	0	0	0	0	159	762	1514	2217	2806	2821	2175	2781	1986	2167	1341	643	104	1	0	0	0	0	21479.	24
26	0	0	0	0	0	0	17	100	418	572	999	1294	1767	2135	1624	301	281	112	254	5	0	0	0	0	9881.	24
27	0	0	0	0	0	1	249	677	1021	1714	2351	1873	2191	2165	1982	1430	1033	395	81	1	0	0	0	0	17165.	24
28	0	0	0	0	0	9999*	285*	839	1666	2415	2577	2285	2830	2379	1926	1851	1512	287	197	1	0	0	0	0	20885.$	22
29	0	0	0	0	0	1	105	176	1287	2212	2572	2805	1230	1231	1904	771	1368	573	160	1	0	0	0	0	16395.	24
30	0	0	0	0	0	1	212	886	1656	2378	2987	3470	2973	3052	1878	1707	1388	345	162	1	0	0	0	0	23097.	24
AV	0	0	0	0	0	0$	108$	512$	1122$	1705	2168$	2392$	2478$	2466$	2234	1672	1212	631	159	1	0	0	0	0	18859.$	
HR	30	30	30	30	30	29	28	29	29	30	29	29	29	29	30	30	30	30	30	30	30	30	30	30		711

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OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 4

GLOBAL (RG630) KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	0	19	362	842	1282	1650	1896	1989	1922	1723	1394	962	449	43	0	0	0	0	0	14533.	24
2	0	0	0	0	0	0	32	186	267	501	599	806	705	674	587	382	240	149	27	0	0	0	0	0	5154.	24
3	0	0	0	0	0	0	3	65	174	217	228	634	777	716	896	436	179	56	5	0	0	0	0	0	4385.	24
4	0	0	0	0	0	0	19	179	418	1166	1539	1900	2042	1996	1778	1465	1030	532	94	0	0	0	0	0	14159.	24
5	0	0	0	0	0	0	36	407	909	1368	1745	1985	2090	2030	1807	1484	1056	556	105	0	0	0	0	0	15577.	24
6	0	0	0	0	0	0	42	355	894	1332	1691	1905	1565	1688	1364	1409	997	516	258$	0	0	0	0	0	14017.	24
7	0	0	0	0	0	0	9999*	9999*	362*	655	557	424	618	330	892	525	516	190	12	0	0	0	0	0	99999.*	21
8	0	0	0	0	0	0	3	13	135	367	229	62	177%	1489	1478	703	289	217	35	0	0	0	0	0	5198.	24
9	0	0	0	0	0	0	52	449	937	1405	1719	1977	1977	1963	1756	1405	1042	552	107	0	0	0	0	0	15342.	24
10	0	0	0	0	0	0	53	445	930	1371	1734	1961	2050	2002	1793	1470	1043	555	106	0	0	0	0	0	15513.	24
11	0	0	0	0	0	0	63	423	886	1328	1695	1915	1987	1839	1505	694	304	112	6	1	0	0	0	0	12757.	24
12	0	0	0	0	0	0	3	4	4	45	47	50	86	290%	276%	191	198	194	14	0	0	0	0	0	1404.	24
13	0	0	0	0	0	0	12	113	278	87	193	58	135	50	29$	7	4	4	4	1	0	0	0	0	974.	24
14	0	0	0	0	0	0	9	84$	158	407	405	489	833	741	434	512	337	136	12	1	0	0	0	0	4556.	24
15	0	0	0	0	0	0	68	470	927	1409	1771	2020	2030	2014	1802	1199%	687	441	91	1	0	0	0	0	14930.	24
16	0	0	0	0	0	0	76	488	993	1433	1796	2037	2128	2064	1861	1534	1101	606	131	1	0	0	0	0	16249.	24
17	0	0	0	0	0	0	56	390	1023	1398	1764	2059	1903	1842	1421	1002	718	580	111	1	0	0	0	0	14269.	24
18	0	0	0	0	0	0	24	129	464	660	995	1279	1587	1144	1131	910	862	364	85	1	0	0	0	0	9636.	24
19	0	0	0	0	0	0	5	53	164	336	1489	1693	1982	1660	1806	1170%	944	515	134	1	0	0	0	0	11953.	24
20	0	0	0	0	0	0	76	475	908	1352	1702	1901	1979	1485%	845%	915	499	641	64	1	0	0	0	0	12842.	24
21	0	0	0	0	0	0	239$	477	896	1346	1658	1772	1963	1893	1779	1435	863%	402	103	1	0	0	0	0	14827.	24
22	0	0	0	0	0	0	253$	506	980	1406	1628*	9999*	9999*	1931*	1768	1463	1040	561	117	1	0	0	0	0	99999.*	20
23	0	0	0	0	0	0	81	480	932	1348	1687	1911	2009	1963	1743	1159	949	495	67	1	0	0	0	0	14825.	24
24	0	0	0	0	0	0	116	452	911	1299	1630	1268	1469	1575	1539%	1093%	910	524	116	1	0	0	0	0	12902.	24
25	0	0	0	0	0	0	85	456	898	1309	1642	1637	1217%	1585	1103	1258%	764%	340	35	1	0	0	0	0	12330.	24
26	0	0	0	0	0	0	4	33	209	289	532	694	970	1178	882	122	120	36	115	1	0	0	0	0	5187.	24
27	0	0	0	0	0	1	118	380	575	976	1370	1061	1248	1223	1119	796	560	200	31	1	0	0	0	0	9659.	24
28	0	0	0	0	0	9999*	178*	521	1010	1450	1521	1310	1649	1356	1086	1050	860	140	94	1	0	0	0	0	12117.$	22
29	0	0	0	0	0	1	59	87	723%	1301%	1508	1637	666	669	1086	418	777	307	81	1	0	0	0	0	9322.	24
30	0	0	0	0	0	1	120	541	996	1423	1765	2040	1725	1772	1053	953	797	165	69	1	0	0	0	0	13422.	24
AV	0	0	0	0	0	0$	62$	311$	670$	1009	1271$	1392$	1433$	1419$	1278	952	688	351	76	1	0	0	0	0	10913.$	
HR	30	30	30	30	30	29	28	29	29	30	29	29	29	29	30	30	30	30	30	30	30	30	30	30		711

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OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 4

DIFFUSE HORIZ. KJ/M2

DAY	HOUR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	0	17	157	252	318	376	392	409	407	388	365	343	266	110	0	0	0	0	0	3800.	24
2	0	0	0	0	0	0	54	331	498	879	1067	1381	1275	1240	1090	752	501	340	90	0	0	0	0	0	9499.	24
3	0	0	0	0	0	0	7	153	361	452	484	1180	1395	1310	1413	846	420	189	46	0	0	0	0	0	8257.	24
4	0	0	0	0	0	0	51	317	654	968	963	354	294	307	327	256	234	178	61	0	0	0	0	0	4964.	24
5	0	0	0	0	0	0	30	156	232	280	310	331	338	306	295	274	241	219	79	0	0	0	0	0	3090.	24
6	0	0	0	0	0	0	29	164	227	292	347	481	1584	1244	784	376	479	456	228$	0	0	0	0	0	6691.	24
7	0	0	0	0	0	0	9999*	9999*	645*	1136	1037	837	1160	676	1461	996	902	369	74	0	0	0	0	0	99999.	*21
8	0	0	0	0	0	0	15	71	307	735	502	205	398	1997	1405	863	596	431	117	0	0	0	0	0	7641.	24
9	0	0	0	0	0	0	39	138	196	327	469	484	707	490	459	375	258	206	96	1	0	0	0	0	4245.	24
10	0	0	0	0	0	0	38	149	210	258	300	344	367	364	359	325	281	212	93	1	0	0	0	0	3300.	24
11	0	0	0	0	0	0	53	170	230	285	336	384	463	1077	1000	1156	617	282	56	1	0	0	0	0	6110.	24
12	0	0	0	0	0	0	4	14	56	179	185	181	257	638	597	441	441	409	74	1	0	0	0	0	3477.	24
13	0	0	0	0	0	0	51	251	541	253	456	228	355	186	129$	71	32	19	16	3	0	0	0	0	2592.	24
14	0	0	0	0	0	0	44	185$	325	598	759	862	1373	1207	810	789	613	289	51	1	0	0	0	0	7906.	24
15	0	0	0	0	0	0	59	218	371	324	321	463	634	969	872	866	727	438	154	1	0	0	0	0	6418.	24
16	0	0	0	0	0	0	70	214	260	314	326	325	344	378	361	329	303	240	116	2	0	0	0	0	3583.	24
17	0	0	0	0	0	0	104	336	382	508	519	668	1024	1228	1236	1242	949	523	143	2	0	0	0	0	8864.	24
18	0	0	0	0	0	0	60	262	813	1121	1276	1398	1718	1491	1667	1337	995	573	147	4	0	0	0	0	12862.	24
19	0	0	0	0	0	0	45	153	346	642	1645	955	757	886	706	786	655	371	175	4	0	0	0	0	8124.	24
20	0	0	0	0	0	0	86	353	433	604	628	659	719	924	1151	885	677	674	167	6	0	0	0	0	7966.	24
21	0	0	0	0	0	0	189$	378	536	540	701	1377	1209	1103	949	655	573	403	173	5	0	0	0	0	8789.	24
22	0	0	0	0	0	0	108$	217	268	318	362*	9999*	9999*	509*	463	392	323	238	130	5	0	0	0	0	99999.	*20
23	0	0	0	0	0	0	99	284	408	506	583	610	615	628	611	807	872	462	155	5	0	0	0	0	6643.	24
24	0	0	0	0	0	0	157	323	457	656	905	1298	1540	1176	981	905	668	375	168	8	0	0	0	0	9616.	24
25	0	0	0	0	0	1	120	353	536	665	783	1270	1256	1385	1499	1166	833	492	136	6	0	0	0	0	10501.	24
26	0	0	0	0	0	1	48	131	437	586	999	1286	1658	1858	1552	345	318	151	278	14	0	0	0	0	9662.	24
27	0	0	0	0	0	1	122	420	794	1109	1068	1290	1562	1404	1540	1208	940	419	105	2	0	0	0	0	11986.	24
28	0	0	0	0	0	9999*	184*	372	448	667	1037	1353	1448	1312	1264	860	833	286	183	2	0	0	0	0	10159.	$22
29	0	0	0	0	0	1	117	198	724	799	992	1184	1159	1220	1380	698	924	484	162	4	0	0	0	0	10047.	24
30	0	0	0	0	0	1	127	320	432	535	642	727	1386	1319	1535	1414	921	374	191	6	0	0	0	0	9929.	24
AV	0	0	0	0	0	0$	69$	234$	405$	562	690$	776$	945$	991$	943	726	582	346	126	3	0	0	0	0	7397.$	
HR	30	30	30	30	30	29	28	29	29	30	29	29	29	29	30	30	30	30	30	30	30	30	30	30		711

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  OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 4

LAT. TILTED KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	HOUR 13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	0	26	556	1461	2352	3108	3630	3813	3677	3284	2618	1750	783	103	0	0	0	0	0	27160.	24
2	0	0	0	0	0	0	47	300	413	798	984	1336	1136	1119	980	641	409	266	60	0	0	0	0	0	8488.	24
3	0	0	0	0	0	0	10	123	305	385	409	1047	1279	1224	1562	769	342	137	28	0	0	0	0	0	7620.	24
4	0	0	0	0	0	0	42	311	724	1975	2795	3633	3901	3796	3397	2731	1859	909	155	0	0	0	0	0	26228.	24
5	0	0	0	0	0	0	47	606	1521	2420	3179	3672	3896	3785	3387	2706	1865	920	162	0	0	0	0	0	28165.	24
6	0	0	0	0	0	0	48	529	1474	2353	3081	3569	2905	3163	2542	2589	1769	859	430$	0	0	0	0	0	25312.	24
7	0	0	0	0	0	0	9999*	9999*	564*	1066	902	719	1004	589	1564	951	854	370	47	0	0	0	0	0	99999.*	21
8	0	0	0	0	0	0	14	49	253	643	439	168	334%	2791	2854	1286	500	408	83	0	0	0	0	0	9821.	24
9	0	0	0	0	0	0	56	637	1537	2449	3114	3627	3615	3698	3253	2543	1818	891	161	1	0	0	0	0	27399.	24
10	0	0	0	0	0	0	57	627	1521	2387	3135	3612	3813	3719	3303	2662	1814	889	155	2	0	0	0	0	27693.	24
11	0	0	0	0	0	0	69	587	1405	2286	3036	3508	3664	3297	2782	1144	516	228	32	2	0	0	0	0	22555.	24
12	0	0	0	0	0	0	13	17	29	134	144	144	219	536	520	345	356	342	50	2	0	0	0	0	2851.	24
13	0	0	0	0	0	0	40	211	486	206	374	177	291	143	90$	38	16	16	16	2	0	0	0	0	2107.	24
14	0	0	0	0	0	0	31	150$	268	696	661	843	1391	1181	749	892	576	252	41	2	0	0	0	0	7733.	24
15	0	0	0	0	0	0	78	636	1476	2421	3153	3657	3700	3593	3204	2097	1140	682	145	2	0	0	0	0	25985.	24
16	0	0	0	0	0	0	80	646	1553	2400	3143	3627	3822	3706	3320	2668	1820	893	164	3	0	0	0	0	27846.	24
17	0	0	0	0	0	0	88	575	1603	2364	3088	3610	3371	3227	2498	1650	1131	844	155	3	0	0	0	0	24206.	24
18	0	0	0	0	0	0	46	219	719	1057	1667	2129	2726	1899	1848	1479	1347	566	121	3	0	0	0	0	15827.	24
19	0	0	0	0	0	0	31	136	330	614	2423	3065	3618	3017	3204	2036	1543	770	175	4	0	0	0	0	20966.	24
20	0	0	0	0	0	0	85	625	1381	2230	2929	3336	3504	2643	1499	1580	807	887	133	4	0	0	0	0	21642.	24
21	0	0	0	0	0	0	308$	616	1345	2231	2873	3065	3433	3271	3126	2468	1419	625	158	4	0	0	0	0	24942.	24
22	0	0	0	0	0	0	322$	643	1473	2289	2731*	9999*	9999*	3401*	3085	2491	1681	807	150	4	0	0	0	0	99999.*	20
23	0	0	0	0	0	0	90	616	1404	2212	2905	3339	3576	3494	3074	2041	1540	768	126	4	0	0	0	0	25190.	24
24	0	0	0	0	0	0	143	602	1382	2166	2817	2254	2550	2835	2704	1903	1488	765	158	5	0	0	0	0	21772.	24
25	0	0	0	0	0	2	103	606	1380	2165	2834	2847	2192	2806	1940	2078	1220	521	84	5	0	0	0	0	20783.	24
26	0	0	0	0	0	2	25	85	345	492	872	1145	1597	1975	1481	272	257	96	211	7	0	0	0	0	8860.	24
27	0	0	0	0	0	2	112	578	931	1595	2304	1786	2095	2107	1860	1301	914	365	82	5	0	0	0	0	16037.	24
28	0	0	0	0	0	9999*	175*	654	1472	2313	2538	2258	2800	2322	1865	1750	1333	263	143	5	0	0	0	0	19800.$	22
29	0	0	0	0	0	3	92	153	1151	2055	2532	2747	1114	1112	1710	683	1207	496	132	5	0	0	0	0	15191.	24
30	0	0	0	0	0	3	123	666	1481	2278	2968	3490	2883	2991	1726	1560	1241	300	146	5	0	0	0	0	21859.	24
AV	0	0	0	0	0	0$	79$	440$	1063$	1701	2221$	2484$	2560$	2542$	2280	1666	1151	564	127	3	0	0	0	0	18881.$	
HR	30	30	30	30	30	29	28	29	29	30	29	29	29	29	30	30	30	30	30	30	30	30	30	30		711

FLAGS:

% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS

* - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS

$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 4

ULTRAVIOLET KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	0	1	22	55	93	127	151	156	147	127	98	64	31	8	0	0	0	0	0	1080.	24
2	0	0	0	0	0	0	2	17	27	50	60	78	71	69	61	42	28	18	5	0	0	0	0	0	528.	24
3	0	0	0	0	0	0	1	7	21	28	31	68	81	77	86	48	25	12	3	0	0	0	0	0	488.	24
4	0	0	0	0	0	0	3	18	39	92	125	155	166	161	141	111	73	37	9	0	0	0	0	0	1128.	24
5	0	0	0	0	0	0	3	25	62	101	136	159	169	163	143	110	73	37	9	0	0	0	0	0	1190.	24
6	0	0	0	0	0	0	3	24	58	96	128	152	135	137	112	106	71	36	18$	0	0	0	0	0	1074.	24
7	0	0	0	0	0	0	9999*	9999*	36*	62	60	52	69	42	85	57	48	24	6	0	0	0	0	0	99999.*	21
8	0	0	0	0	0	0	1	5	18	42	31	14	26	137	131	66	33	25	7	0	0	0	0	0	535.	24
9	0	0	0	0	0	0	4	29	64	104	136	161	163	161	140	108	74	38	10	0	0	0	0	0	1193.	24
10	0	0	0	0	0	0	4	29	64	101	136	159	167	162	140	111	74	38	11	0	0	0	0	0	1195.	24
11	0	0	0	0	0	0	4	26	53	90	125	146	153	141	115	61	32	15	4	0	0	0	0	0	966.	24
12	0	0	0	0	0	0	0	1	4	13	14	14	19	45	40	29	28	24	5	0	0	0	0	0	237.	24
13	0	0	0	0	0	0	4	15	32	18	31	17	25	14	10$	6	2	1	1	0	0	0	0	0	178.	24
14	0	0	0	0	0	0	3	11$	20	44	48	56	92	81	52	54	38	17	3	0	0	0	0	0	519.	24
15	0	0	0	0	0	0	5	31	67	111	148	173	175	167	145	100	59	35	10	0	0	0	0	0	1228.	24
16	0	0	0	0	0	0	6	31	68	106	141	165	174	166	147	116	78	40	12	0	0	0	0	0	1251.	24
17	0	0	0	0	0	0	5	29	69	104	137	161	154	146	114	81	54	38	12	0	0	0	0	0	1104.	24
18	0	0	0	0	0	0	2	16	41	60	86	107	129	98	92	74	59	28	6	0	0	0	0	0	800.	24
19	0	0	0	0	0	0	4	11	20	37	116	140	162	135	136	94	66	36	11	0	0	0	0	0	969.	24
20	0	0	0	0	0	0	6	30	62	95	124	142	151	121	82	72	44	32%	10	1	0	0	0	0	972.	24
21	0	0	0	0	0	0	15$	30	59	95	123	135	145	140	129	102	62	32	11	1	0	0	0	0	1076	24
22	0	0	0	0	0	0	16$	33	65	95	111*	9999*	9999*	142*	127	102	69	36	13	1	0	0	0	0	99999.*	20
23	0	0	0	0	0	0	8	31	61	93	121	137	149	146	126	87	66	36	12	1	0	0	0	0	1074.	24
24	0	0	0	0	0	0	9	32	62	94	121	106	118	125	119	87	66	37	13	1	0	0	0	0	988.	24
25	0	0	0	0	0	0	8	32	65	99	127	128	110	131	97	88	56	31	11	1	0	0	0	0	985.	24
26	0	0	0	0	0	0	2	8	26	35	57	73	95	111	88	22	19	9	13	1	0	0	0	0	557.	24
27	0	0	0	0	0	0	10	35	52	89	116	101	118	117	104	76	57	24	7	0	0	0	0	0	906.	24
28	0	0	0	0	0	9999*	13*	35	73	111	125	121	140	122	101	89	68	18	12	0	0	0	0	0	1021.$	22
29	0	0	0	0	0	0	6	12	63	103	128	138	73	72	97	42	66	30	9	0	0	0	0	0	839.	24
30	0	0	0	0	0	0	10	38	73	109	143	166	146	145	98	89	62	23	11	1	0	0	0	0	1114.	24
V	0	0	0	0	0	0$	5$	23$	50$	79	104$	116$	122$	120$	106	78	54	28	9	0	0	0	0	0	893.$	
R	30	30	30	30	30	29	28	29	29	30	29	29	29	29	30	30	30	30	30	30	30	30	30	30		711

LAGS:
- QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
- BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
- ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
  OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 4

AVAILABLE SUNSHINE %

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVG	HR
1	0	0	0	0	0	0	44	97	100	100	100	100	100	100	100	100	100	100	6	0	0	0	0	0	91.	24
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	24
3	0	0	0	0	0	0	0	0	0	0	0	0	2	2	16	1	0	0	0	0	0	0	0	0	2.	24
4	0	0	0	0	0	0	0	16	12	79	94	100	100	100	100	100	100	100	73	0	0	0	0	0	78.	24
5	0	0	0	0	0	0	58	100	100	100	100	100	100	100	100	100	100	100	75	0	0	0	0	0	96.	24
6	0	0	0	0	0	0	65	93	100	100	100	100	50	79	64	100	100	100	0	0	0	0	0	0	85.	24
7	0	0	0	0	0	0	0	0	40	0	0	0	0	0	11	0	21	4	0	0	0	0	0	0	6.	24
8	0	0	0	0	0	0	0	0	0	0	0	0	1	61	74	24	0	6	0	0	0	0	0	0	13.	24
9	0	0	0	0	0	0	74	100	100	100	97	99	89	97	96	95	100	100	73	0	0	0	0	0	94.	24
10	0	0	0	0	0	0	66	100	100	100	100	100	100	100	100	100	100	100	71	0	0	0	0	0	96.	24
11	0	0	0	0	0	0	59	100	100	100	100	100	100	100	100	6	0	0	0	0	0	0	0	0	67.	24
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	24
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	24
14	0	0	0	0	0	0	0	0	0	11	0	2	5	6	0	7	2	0	0	0	0	0	0	0	3.	24
15	0	0	0	0	0	0	53	100	99	100	100	99	94	90	90	66	41	52	19	0	0	0	0	0	77.	24
16	0	0	0	0	0	0	53	100	100	100	100	100	100	100	100	100	100	100	66	0	0	0	0	0	94.	24
17	0	0	0	0	0	0	0	68	100	100	100	100	99	91	84	46	33	84	55	0	0	0	0	0	74.	24
18	0	0	0	0	0	0	0	0	0	2	38	45	86	39	9	6	69	18	4	0%	0	0	0	0	24.	24
19	0	0	0	0	0	0	0	0	0	0	50	81	96	76	100	69	81	92	53	0	0	0	0	0	54.	24
20	0	0	0	0	0	0	30	98	100	100	100	100	97	65	23	44	36	97	3	0	0	0	0	0	68.	24
21	0	0	0	0	0	0	11	100	100	100	100	75	93	92	98	99	82	75	39	0	0	0	0	0	82.	24
22	0	0	0	0	0	0	31	100	100	100	100	100	100	100	100	100	100	100	73	0	0	0	0	0	92.	24
23	0	0	0	0	0	0	39	100	100	100	100	100	100	100	100	76	96	91	14	0	0	0	0	0	85.	24
24	0	0	0	0	0	0	39	90	100	100	100	53	55	74	81	64	84	96	62	0	0	0	0	0	76.	24
25	0	0	0	0	0	0	31	100	100	100	100	76	51	74	32	81	64	53	0	0	0	0	0	0	65.	24
26	0	0	0	0	0	0%	0	0	0	0	0	0	0	8	5	0	0	0	1	0	0	0	0	0	1.	24
27	0	0	0	0	0	0	58	41	19	37	55	23	27	29	22	17	7	0	0	0	0	0	0	0	25.	24
28	0	0	0	0	0	0	10	100	100	95	72	43	59	45	33	56	59	4	14	0	0	0	0	0	53.	24
29	0	0	0	0	0	0	0	0	47	78	69	62	4	0	29	8	41	16	7	0	0	0	0	0	27.	24
30	0	0	0	0	0	0	43	98	100	100	100	100	61	68	19	18	36	0	0	0	0	0	0	0	55.	24
AV	0	0	0	0	0	0	26	59	61	63	65	61	58	59	57	49	52	50	24	0	0	0	0	0	53.	
HR	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30		720

FLAGS:

% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
+ - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

T 3% ERROR IN MONTHLY AVG:
AILY AVG = 49.

ATLANTA (GA TECH) YEAR 1980 MONTH 5

DIRECT NORMAL KJ/M2

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
0	0	0	0	0	7	700	1503	1749	2479	2341	2199	2002	2734	2091	1570	1559	1416	624	6	0	0	0	0	22980.	24
0	0	0	0	0	3	322	1481	2118	2458	2685	2726	2182	2643	2482	1849	1133	521	173	2	0	0	0	0	22776.	24
0	0	0	0	0	1	3	3	3	5	108	1448	693	1018	499	889	239	259	6	1	0	0	0	0	5174.	24
0	0	0	0	0	1	276	440	262	924	2039	2142	1549	1286	682	86	19	3	3	1	0	0	0	0	9712.	24
0	0	0	0	0	1	496$	992	1441	1583	1771	1987	2023	2140	886	464	507	528	7	1	0	0	0	0	14926.	24
0	0	0	0	0	4	557	1084	1645	2290	2442	2363	2196	1901	1814	1849	1770	1797	934	29	0	0	0	0	22675.	24
0	0	0	0	0	11	811	1935	1555	2087	2279	1718	1936	684	696	129	16	3	3	1	0	0	0	0	13865.	24
0	0	0	0	0	1	7	79	61	16	3	4	736	1850	2555	2146	1551	1770	310	53	0	0	0	0	11143.	24
0	0	0	0	0	1	84	1781	2362	2583	2540	2809	2807	2994	2969	2805	2560	2271	1469	125	0	0	0	0	30159.	24
0	0	0	0	0	29	1065	2037	2556	2810	3015	3081	3075	3085	3016	2869	2578	2125	1231	99	0	0	0	0	32672.	24
0	0	0	0	0	27	1016	1834	2223	2579	2862	2995	3030	2643	2348	1894	1496	795	10	1	0	0	0	0	25753.	24
0	0	0	0	0	9999*	169*	984	331	2147	2985	2347	1133	1577	417	881	1859	66	3	1	0	0	0	0	15085.$	22
0	0	0	0	0	1	3	3	3	3	3	26	88	7	4	3	3	3	3	1	0	0	0	0	154.	24
0	0	0	0	0	1	3	3	3	3	3	3	8	3	3	3	3	3	3	1	0	0	0	0	43.	24
0	0	0	0	0	1	3	77	701	759	68	358	842	1121	1521	669	212	560	700	52	0	0	0	0	7644.	24
0	0	0	0	0	1	3	3	3	3	3	10	55	33	8	3	3	3	3	2	0	0	0	0	134.	24
0	0	0	0	0	1	3	3	3	3	3	3	3	3	3	47	26	3	5	12	0	0	0	0	120.	24
0	0	0	0	0	1$	3	3	10	719	1862	2045	2582	1794	2360	2682	912	1295	853	13	0	0	0	0	17134.	24
0	0	0	0	0	1	3	33	4	3	41	14	5	39	3	3	3	3	3	2	0	0	0	0	159.	24
0	0	0	0	0	1	3	3	3	3	60	137	16	351	1274	1770	1321	1986	946	96	0	0	0	0	7958.	24
0	0	0	0	0	29	720	1482	2080	2127	2486	2395	2608	2383	1600	1987	1433	807	128	12	0	0	0	0	22276.	24
0	0	0	0	0	1	3	3	3	3	3	3	3	3	3	3	25	3	3	2	0	0	0	0	62.	24
0	0	0	0	0	1	6	61	342	3	3	12	33	3	3	3	3	1129	82	2	0	0	0	0	1685.	24
0	0	0	0	0	1	77	762	1199	1139	1494	1092	837	914	815	728	883	693	272	2	0	0	0	0	10908.	24
0	0	0	0	0	1	204	647	1025	1088	1212	1092	915	780	857	1466	1488	805	413	22	0	0	0	0	12014.	24
0	0	0	0	0	4	285	830	1291	1706	1929	1867	1201	1958	1932	1296	1463	1123	578	62	0	0	0	0	17525.	24
0	0	0	0	0	1	3	155	93	34	731	1347	877	889	564	1196	981	1084	586	43	0	0	0	0	8584.	24
0	0	0	0	0	18	349	518	105	355	428	218	356	1238	3	3	3	15	186	31	0	0	0	0	3823.	24
0	0	0	0	0	9	330	875	1096	1031	399	1467	1177	618	1010	1049	487	346	201	2	0	0	0	0	10095.	24
0	0	0	0	0	8	476$	944	1776	2138	2305	2312	1869	2059	1655	1959	1477	719	404	7	0	0	0	0	20108.	24
0	0	0	0	0	13	619	1370	1905	2145	935	479	412	1451	1361	629	440	489	14	35	0	0	0	0	12297.	24
0	0	0	0	0	6$	281$	707	902	1136	1259	1313	1202	1297	1143	1062	856	730	328	23	0	0	0	0	12245.$	
31	31	31	31	31	30	30	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31		742

AGS:
- QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
- BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
- ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
  OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH)   YEAR 1980   MONTH 5

DIRECT (RG630) KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	HOUR 13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	9	638	1196	1259	1708	1563	1454	1301	1768	1387	1096	1159	1149	574	8	0	0	0	0	16272.	24
2	0	0	0	0	0	4	294	1210	1574	1734	1834	1828	1480	1788	1683	1272	847	449	163	3	0	0	0	0	16161.	24
3	0	0	0	0	0	2	6	6	6	7	78	1034	477	756	383	703	204	230	10	2	0	0	0	0	3905.	24
4	0	0	0	0	0	2	188	281	155	560	1324	1494	1129	962	521	77	20	6	6	3	0	0	0	0	6728.	24
5	0	0	0	0	0	2	438$	874	1173	1249	1351	1470	1470	1550	671	367	519	491	10	3	0	0	0	0	11537.	24
6	0	0	0	0	0	5	517	934	1290	1628	1696	1643	1515	1312	1256	1300	1276	1350	799	33	0	0	0	0	16553.	24
7	0	0	0	0	0	13	675	1384	1031	1341	1449	1107	1245	445	452	89	15	6	6	3	0	0	0	0	9260.	24
8	0	0	0	0	0	2	10	63	47	13	6	6	447	1155	1600	1367	1035	1264	261	54	0	0	0	0	7331.	24
9	0	0	0	0	0	2	61	1216	1540	1673	1614	1772	1760	1870	1887	1818	1716	1590	1155	120	0	0	0	0	19795.	24
0	0	0	0	0	0	29	844	1387	1622	1759	1873	1906	1894	1893	1853	1786	1661	1453	954	96	0	0	0	0	21009.	24
1	0	0	0	0	0	18*	564*	856*	949*	1145*	1417*	1650*	1784	1660	1530	1244	1058	623	14	3	0	0	0	0	99999.	*17
2	0	0	0	0	0	9999*	68*	605	200	1304	1801	1410	655	928	250	541	1180	50	7	3	0	0	0	0	9187.	$22
3	0	0	0	0	0	2	6	6	6	6	6	17	54	8	7	6	6	6	6	3	0	0	0	0	145.	24
4	0	0	0	0	0	2	6	6	6	6	6	6	6	6	6	6	6	6	6	3	0	0	0	0	84.	24
5	0	0	0	0	0	2	6	48	475	508	46	239	559	747	1005	445	156	428	595	59	0	0	0	0	5320.	24
6	0	0	0	0	0	3	6	6	6	6	6	11	42	27	10	6	6	6	6	3	0	0	0	0	149.	24
7	0	0	0	0	0	3	6	6	6	6	6	6	6	6	6	31	17	6	6	3	0	0	0	0	121.	24
8	0	0	0	0	0	3$	6	6	10	459	1191	1295	1625	1143	1530	1755	619	951	725	22	0	0	0	0	11340.	24
9	0	0	0	0	0	3	6	26	7	6	32	13	7	28	6	6	6	6	6	4	0	0	0	0	161.	24
0	0	0	0	0	0	3	6	6	6	6	31	72%	12	210	808	1132	887	1449	813	103	0	0	0	0	5544.	24
1	0	0	0	0	0	34	671	1207	1555	1519	1751	1692	1810	1655	1164	1490	1182	748%	151	21	0	0	0	0	16650.	24
2	0	0	0	0	0	3	6	6	6	6	6	6	6	6	6	6	11	6	6	4	0	0	0	0	90.	24
3	0	0	0	0	0	3	9	49	247	6	6	11	23	6	6	6	6	857	77	4	0	0	0	0	1317.	24
4	0	0	0	0	0	3	73	642	909	851	1127	834	639	721	638	580	750	638	279	4	0	0	0	0	8688.	24
5	0	0	0	0	0	3	209	593	838	854	925	794	675	581	656	1151	1187	685	415	31	0	0	0	0	9597.	24
6	0	0	0	0	0	6	291	764%	1095%	1377	1524	1417	902	1421	1404	991	1176	977	574	77	0	0	0	0	13996.	24
7	0	0	0	0	0	3	6	156	89	34	602	1066	690	691	449	946	808	948%	575	56	0	0	0	0	7119.	24
8	0	0	0	0	0	25	346	471	90	291	332	170	287	955	6	6	7	18	198	37	0	0	0	0	3238.	24
9	0	0	0	0	0	14	329	789	937%	844%	320	1147	918	508	827%	874%	432	333	216	4	0	0	0	0	8491.	24
0	0	0	0	0	0	12	393$	775	1335	1525	1603	1577	1272	1415	1151	1400	1133	613	401	13	0	0	0	0	14617.	24
1	0	0	0	0	0	15	548	1062	1356	1447	624	326	286	986	940	454	344	404	23	42	0	0	0	0	8859.	24
V	0	0	0	0	0	7$	228$	526$	629$	758$	824$	861$	806	878	777	740	627	572	292	27	0	0	0	0	8551.$	
R	31	31	31	31	31	29	29	30	30	30	30	30	31	31	31	31	31	31	31	31	31	31	31	31		735

LAGS:

- QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
- BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
- ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 5

GLOBAL HORIZ. KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	1	236	883	1498	2389	2913	3165	3290	3804	3032	2181	1783	999	273	3	0	0	0	0	26452.	24
2	0	0	0	0	0	1	221	875	1643	2355	2955	3338	3236	3517	2986	2171	1382	720	241	5	0	0	0	0	25645.	24
3	0	0	0	0	0	1	9	113	91	741	1418	2994	2470	2800	1700	1964	863	622	69	2	0	0	0	0	15856.	24
4	0	0	0	0	0	1	207	699	1049	1851	2803	3203	2854	2675	1838	827	833	188	9	2	0	0	0	0	19038.	24
5	0	0	0	0	0	1	409$	816	1511	2202	2703	3142	3282	3416	1948	1338	1122	745	46	2	0	0	0	0	22682.	24
6	0	0	0	0	0	1	229	847	1565	2309	2866	3191	3256	2910	2609	2253	1609	1091	334	6	0	0	0	0	25077.	24
7	0	0	0	0	0	3	258	983	1489	2301	2878	2822	3005	1939	2297	1286	852	300	56	2	0	0	0	0	20472.	24
8	0	0	0	0	0	1	77	471	674	757	271	774	2317	3158	3018	2289	1588	1210	247	16	0	0	0	0	16866.	24
9	0	0	0	0	0	2	171	926	1724	2445	2890	3428	3376	3382	3060	2525	1841	1131	406	11	0	0	0	0	27316.	24
10	0	0	0	0	0	3	296	1006	1789	2489	3088	3475	3574	3476	3130	2580	1870	1112	373	13	0	0	0	0	28275.	24
11	0	0	0	0	0	4	297	958	1698	2400	2992	3366	3517	3343	2956	2319	1650	880	155	2	0	0	0	0	25537.	24
12	0	0	0	0	0	9999*	300*	930	1049	2170	3049	3201	2855	3023	1879	1999	1771	492	190	3	0	0	0	0	22856.$	22
13	0	0	0	0	0	2	64	171	431	536	914	1268	1372	1082	1176	784	770	421	81	5	0	0	0	0	9076.	24
14	0	0	0	0	0	2	125	372	694	650	106	215	1141	903	486	404	305	153	57	3	0	0	0	0	5616.	24
15	0	0	0	0	0	2	185	704	1391	1807	1409	2111	2600	2726	2695	1828	1065	838	397	27	0	0	0	0	19783.	24
16	0	0	0	0	0	2	50	136	328	864	1200	1217	1728	1333	1169	697	683	374	119	2	0	0	0	0	9903.	24
17	0	0	0	0	0	2	4	20	35	193	228	395	232	130	223	785	816	168	37	37	0	0	0	0	3304.	24
18	0	0	0	0	0	31$	63	151	436	1836	2526	2959	3643	2738	3070	2791	1065	901	462	25	0	0	0	0	22698.	24
19	0	0	0	0	0	2	123	515	476	750	845	939	994	613	307	525	328	93	148	2	0	0	0	0	6658.	24
20	0	0	0	0	0	2	4	38	127	537	1258	1489	1246	1864	2229	2092	1431	1173	428	25	0	0	0	0	13942.	24
21	0	0	0	0	0	11	319	986	1738	2349	2959	3209	3538	3426	2644	2591	1772	928	282	26	0	0	0	0	26777.	24
22	0	0	0	0	0	2	103	181	323	239	247	681	915	975	784	944	510	104	16	4	0	0	0	0	6028.	24
23	0	0	0	0	0	2	137	438	1041	609	565	780	1396	441	27	207	396	1172	296	3	0	0	0	0	7510.	24
24	0	0	0	0	0	2	153	865%	1507%	1943	2798	2766	2585	2693	2401	1948	1619	977	330	12	0	0	0	0	22596.	24
25	0	0	0	0	0	19	373	950	1500	2075	2700	2550	2605	2390	2205	2419	1795	1024	355	15	0	0	0	0	22975.	24
26	0	0	0	0	0	12	269	843	1526	2178	2730	3074	2678	3204	2876	2135	1740	1048	403	34	0	0	0	0	24750.	24
27	0	0	0	0	0	4	169	560	661	971	2128	2955	2846	2611	2084	2218	1553	1036	395	25	0	0	0	0	20215.	24
28	0	0	0	0	0	15	336	817	1040	1655	2218	2126	2183	2778	625	223	301	335	361	55	0	0	0	0	15069.	24
29	0	0	0	0	0	13	284	868	1531	2047	1978	2948	2761	2080	2568	2151	1251	706	303	21	0	0	0	0	21511.	24
30	0	0	0	0	0	8	413$	819	1643	2319	2849	3241	3151	3251	2749	2700	1755	907	446	20	0	0	0	0	26271.	24
31	0	0	0	0	0	10	321	964	1678	2412	2095	1724	1728	2900	2526	1652	932	622	187	53	0	0	0	0	19803.	24
AV	0	0	0	0	0	5$	197$	642	1093	1625	2019	2347	2464	2438	2042	1704	1202	725	242	15	0	0	0	0	18759.$	
HR	31	31	31	31	31	30	30	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31		742

FLAGS:
% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
* - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
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OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH)   YEAR 1980   MONTH 5

GLOBAL (RG630) KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
												HOUR														
1	0	0	0	0	0	1	139	544	901	1432	1725	1858	1923	2226	1768	1262	1049	583	133	1	0	0	0	0	15546.	24
2	0	0	0	0	0	1	127	544	1008	1430	1766	1976	1922%	2074	1764	1244%	788	399	113	2	0	0	0	0	15158.	24
3	0	0	0	0	0	1	4	42	25	402	810	1776	1405	1660	994	1153	497	358	20	2	0	0	0	0	9149.	24
4	0	0	0	0	0	1	122	430	606	1113	1694	1910	1690%	1562%	1020%	428	432	77	4	2	0	0	0	0	11091.	24
5	0	0	0	0	0	1	253$	506	931	1359	1648	1876	1929	2027	1110%	736%	623%	413%	13	2	0	0	0	0	13428.	24
6	0	0	0	0	0	1	133	528	961	1385	1700	1878	1907	1756	1537	1323%	918%	625	165	2	0	0	0	0	14819.	24
7	0	0	0	0	0	1	145	598	877	1356	1677	1615	1731	1083	1299	703	455	136	10	2	0	0	0	0	11686.	24
8	0	0	0	0	0	1	33	246	361	402	111	390	1307	1826	1747	1309	914	716	108	6	0	0	0	0	9476.	24
9	0	0	0	0	0	1	86	577	1057	1486	1735	2064	2058	2001	1821	1497	1090	661	216	2	0	0	0	0	16351.	24
10	0	0	0	0	0	1	176	618	1078	1486	1819	2040	2087	2016	1813	1486	1071	628	190	3	0	0	0	0	16511.	24
11	0	0	0	0	0	2	170	577	1007	1409	1741	1954	2019	1914	1691	1320	938	480	55	2	0	0	0	0	15279.	24
12	0	0	0	0	0	9999*	151*	558	592	1268	1771	1849	1622	1718	1043	1117	988	240	74	2	0	0	0	0	12977.$	22
13	0	0	0	0	0	2	20	70	207	266	478	682	738	565%	616%	397	403	208	18	2	0	0	0	0	4670.	24
14	0	0	0	0	0	2	54	189	367	331	15	69	591%	462%	216	170	123	43	7	2	0	0	0	0	2642.	24
15	0	0	0	0	0	2	84	384	803	1031	769	1179	1472	1544	1535	1027	572	453	200	7	0	0	0	0	11062.	24
16	0	0	0	0	0	2	14	50	147	437%	632%	642%	934	703%	609%	343	344	177	47	2	0	0	0	0	5083.	24
17	0	0	0	0	0	2	4	4	5	57	71	147%	69	13	65	375%	410%	56	5	18	0	0	0	0	1301.	24
18	0	0	0	0	0	8$	16	57	216	1050	1466	1697%	2109	1557%	1765	1600	538%	478%	241	5	0	0	0	0	12804.	24
19	0	0	0	0	0	2	49	261	234	375%	419%	481%	513%	308	119	237	143	25	54	2	0	0	0	0	3224.	24
20	0	0	0	0	0	2	4	4	24	236%	655%	811	643%	1018	1244	1154	785%	660	220	6	0	0	0	0	7465.	24
21	0	0	0	0	0	4	175	601	1048	1417	1752	1902	2072	1999	1529%	1507	1030	530	131	6	0	0	0	0	15705.	24
22	0	0	0	0	0	2	41	73	146	100	79	294%	443%	478%	366%	451%	229%	13	4	2	0	0	0	0	2722.	24
23	0	0	0	0	0	2	54	225	588	303	264	383%	743	187%	4	75	169	674	143	2	0	0	0	0	3815.	24
24	0	0	0	0	0	2	77	507	924	1138	1640	1592	1485	1560	1367	1098	923	554	162	2	0	0	0	0	13030.	24
25	0	0	0	0	0	10	231	583	885	1216	1579	1464	1482	1351	1237	1384	1016	565	173	3	0	0	0	0	13177.	24
26	0	0	0	0	0	4	153	515	929	1337*	1662*	1815	1570	1873	1668	1246%	1001	600	212	10	0	0	0	0	14410.$	22
27	0	0	0	0	0	2	86	337	386	555	1249	1744	1663	1521	1216	1314%	920%	613	208	7	0	0	0	0	11818.	24
28	0	0	0	0	0	8	196	487	605	988	1309	1222	1258	1642	310	90	137	164	202	26	0	0	0	0	8643.	24
29	0	0	0	0	0	5	161	525	921	1208	1134	1692	1606%	1198%	1509	1265	698%	381	146	3	0	0	0	0	12451.	24
30	0	0	0	0	0	2	245$	488	994	1386	1693	1902	1832	1900	1602	1590	1017	520	246	3	0	0	0	0	15420.	24
31	0	0	0	0	0	3	182	577	995	1426	1214	963%	965	1698	1467%	944	541	371	82	25	0	0	0	0	11454.	24
AV	0	0	0	0	0	3$	108$	378	640	935$	1154$	1351	1413	1401	1163	963	670	400	116	5	0	0	0	0	10697.$	
HR	31	31	31	31	31	30	30	31	31	30	30	31	31	31	31	31	31	31	31	31	31	31	31	31		740

FLAGS:

% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS

* - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS

$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 5

DIFFUSE HORIZ. KJ/M2

HOUR

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
0	0	0	0	0	2	148	412	555	675	959	1129	1355	1241	1227	1037	907	491	186	9	0	0	0	0	10336.	24
0	0	0	0	0	2	178	388	541	653	724	837	1153	1051	870	801	728	552	240	13	0	0	0	0	8730.	24
0	0	0	0	0	1	25	139	116	741	1311	1630	1779	1848	1286	1326	753	560	116	8	0	0	0	0	11638.	24
0	0	0	0	0	2	180	579	901	1195	1110	1235	1388	1491	1266	814	862	240	31	2	0	0	0	0	11297.	24
0	0	0	0	0	3	250$	496	764	1119	1250	1327	1361	1430	1201	1013	828	571	84	2	0	0	0	0	11698.	24
0	0	0	0	0	3	159	497	689	705	826	1004	1143	1129	1052	897	630	434	198	17	0	0	0	0	9382.	24
0	0	0	0	0	7	154	342	669	830	963	1238	1152	1306	1672	1205	873	349	103	9	0	0	0	0	10874.	24
0	0	0	0	0	2	102	457	660	760	297.	778	1559	1368	785	671	687	525	221	24	0	0	0	0	8895.	24
0	0	0	0	0	3	174	364%	465	607	744	811	672	556	498	462	387	280	161	16	0	0	0	0	6199.	24
0	0	0	0	0	7	198%	330%	409	491	526	586	586	554	513	460	396	311	177	22	0	0	0	0	5565.	24
0	0	0	0	0	7	217%	351%	479	560	565	566	579	846	928	924	812	598	213	18	0	0	0	0	7664.	24
0	0	0	0	0	9999*	286*	635	879	624	534	1008	1736	1508	1519	1352	689	514	242	17	0	0	0	0	11463.$	22
0	0	0	0	0	5	102	206	461	563	932	1251	1300	1104	1195	820	798	462	126	17	0	0	0	0	9344.	24
0	0	0	0	0	3	154	400	717	676	155	255	1130	915	511	432	335	184	87	12	0	0	0	0	5964.	24
0	0	0	0	0	6	206	669	990	1286	1366	1764	1774	1657	1362	1336	986	609	243	27	0	0	0	0	14280.	24
0	0	0	0	0	3	81	167	354	878	1202	1213	1656	1306	1176	726	713	411	158	4	0	0	0	0	10049.	24
0	0	0	0	0	3	28	57	71	225	261	425	268	166	257	776	819	206	77	52	0	0	0	0	3691.	24
0	0	0	0	0	49$	97	184	458	1285	945	1026	1111	1050	993	779	563	442	314	51	0	0	0	0	9347.	24
0	0	0	0	0	2	152	528	504	774	830	942	1010	611	347	555	360	125	180	9	0	0	0	0	6930.	24
0	0	0	0	0	2	19	73	160	561	1203	1349	1230	1498	1080	723	670	377	249	35	0	0	0	0	9229.	24
0	0	0	0	0	18	203	453	602	850	841	971	1007	1166	1274	1111	944	642	295	48	0	0	0	0	10423.	24
0	0	0	0	0	6	135	209	348	266	278	700	929	986	803	960	533	140	43	16	0	0	0	0	6352.	24
0	0	0	0	0	6	169	441	865	637	589	786	1365	474	63	240	425	760	312	13	0	0	0	0	7143.	24
0	0	0	0	0	5	171	608%	882%	1114	1500	1717	1754	1806	1680	1397	1105	713	301	31	0	0	0	0	14783.	24
0	0	0	0	0	28	356	725	916	1291	1640	1493	1689	1633	1448	1297	918	697	309	33	0	0	0	0	14472.	24
0	0	0	0	0	21	236	545	806	1191	1451	1299	1478	1301	1124	1190	892	617	320	58	0	0	0	0	12529.	24
0	0	0	0	0	13	202	524	634	964	1487	1680	2001	1725	1569	1273	999	628	312	50	0	0	0	0	14059.	24
0	0	0	0	0	27	296	661	997	1398	1846	1931	1878	1559	685	280	347	375	360	79	0	0	0	0	12718.	24
0	0	0	0	0	22	242	558	940	1333	1636	1587	1637	1526%	1682	1367	990	599	301	53	0	0	0	0	14472.	24
0	0	0	0	0	17	256$	495	661	779	882	1060	1314	1271	1281	1214	885	632	405	51	0	0	0	0	11203.	24
0	0	0	0	0	18	229	464	618	865	1320	1300	1348	1510	1347	1176	711	444	231	76	0	0	0	0	11656.	24
0	0	0	0	0	10$	171$	418	616	835	973	1126	1301	1213	1055	923	727	467	213	28	0	0	0	0	10076.$	
31	31	31	31	31	30	30	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31		742

GS:

QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS

BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS

ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS

OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 5

LAT. TILTED KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	HOUR 13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	4	156	700	1359	2262	2886	3193	3273	3708	2976	2081	1558	792	176	6	0	0	0	0	25130.	24
2	0	0	0	0	0	3	161	672	1459	2210	2869	3329	3221	3501	2932	2086	1249	590	197	8	0	0	0	0	24487.	24
3	0	0	0	0	0	4	20	126	88	634	1312	3038	2556	2712	1677	1829	832	573	75	6	0	0	0	0	15482.	24
4	0	0	0	0	0	4	146	591	952	1744	2738	3183	2837	2604	1792	728	709	171	17	6	0	0	0	0	18222.	24
5	0	0	0	0	0	4	322$	639	1329	2091	2619	3085	3270	3362	1880	1288	991	611	60	7	0	0	0	0	21557.	24
6	0	0	0	0	0	5	136	645	1362	2152	2774	3153	3227	2854	2510	2111	1409	811	183	8	0	0	0	0	23340.	24
7	0	0	0	0	0	5	131	706	1297	2162	2803	2722	2967	1919	2149	1146	752	276	55	7	0	0	0	0	19097.	24
8	0	0	0	0	0	5	69	407	614	753	252	677	2207	3096	2914	2102	1371	904	190	14	0	0	0	0	15575.	24
9	0	0	0	0	0	5	131	661	1465	2241	2769	3337	3337	3307	2928	2317	1573	803	181	9	0	0	0	0	25064.	24
10	0	0	0	0	0	5	137	694	1499	2262	2918	3362	3476	3366	2972	2349	1582	782	173	10	0	0	0	0	25589.	24
11	0	0	0	0	0	6	141	667	1419	2182	2821	3257	3421	3224	2803	2120	1420	691	129	7	0	0	0	0	24308.	24
12	0	0	0	0	0	9999*	234*	706	910	1975	2897	3099	2702	2918	1735	1825	1510	429	161	9	0	0	0	0	21057.$	22
13	0	0	0	0	0	6	66	169	380	494	806	1090	1210	921	997	684	664	377	75	10	0	0	0	0	7949.	24
14	0	0	0	0	0	6	109	317	625	612	91	193	993	736	405	354	257	136	50	8	0	0	0	0	4891.	24
15	0	0	0	0	0	6	165	573	1195	1632	1266	1931	2434	2590	2554	1658	929	657	250	25	0	0	0	0	17865.	24
16	0	0	0	0	0	7	55	129	290	755	1043	1038	1540	1192	1015	606	601	326	113	9	0	0	0	0	8718.	24
17	0	0	0	0	0	7	17	24	40	164	194	333	197	114	194	671	716	149	36	32	0	0	0	0	2888.	24
18	0	0	0	0	0	32$	63	139	412	1638	2339	2812	3470	2617	2904	2519	959	683	287	21	0	0	0	0	20895.	24
19	0	0	0	0	0	7	114	444	430	649	761	802	907	585	272	448	305	85	131	10	0	0	0	0	5951.	24
20	0	0	0	0	0	8	16	40	113	456	1115	1389	1095	1666	2044	1892	1188	812	223	18	0	0	0	0	12074.	24
21	0	0	0	0	0	11	176	681	1420	2110	2749	3046	3349	3217	2430	2322	1496	707	219	24	0	0	0	0	23955.	24
22	0	0	0	0	0	8	92	162	279	208	224	581	770	821	661	806	449	94	24	11	0	0	0	0	5191.	24
23	0	0	0	0	0	8	121	370	881	513	492	711	1224	342	33	183	345	861	266	11	0	0	0	0	6362.	24
24	0	0	0	0	0	8	130	587	1284	1722	2543	2558	2408	2472	2158	1680	1326	724	208	14	0	0	0	0	19822.	24
25	0	0	0	0	0	21	295	710	1244	1801	2479	2371	2422	2216	2036	2132	1483	773	230	16	0	0	0	0	20230.	24
26	0	0	0	0	0	14	185	622	1265	1897	2416	2903	2525	3017	2652	1894	1459	769	250	28	0	0	0	0	21897.	24
27	0	0	0	0	0	10	150	473	603	881	1966	2771	2656	2436	1911	1948	1294	749	239	24	0	0	0	0	18110.	24
28	0	0	0	0	0	16	223	616	895	1455	2015	1954	2023	2597	585	192	247	272	258	46	0	0	0	0	13394.	24
29	0	0	0	0	0	14	184	624	1242	1789	1772	2755	2574	1907	2305	1856	1038	549	207	19	0	0	0	0	18836.	24
30	0	0	0	0	0	11	287$	564	1302	1985	2565	2980	2928	3022	2488	2311	1424	679	299	22	0	0	0	0	22866.	24
31	0	0	0	0	0	12	170	635	1316	2013	1846	1561	1564	2675	2268	1438	840	463	159	49	0	0	0	0	17008.	24
AV	0	0	0	0	0	9$	139$	487	934	1466	1882	2233	2348	2313	1909	1535	1031	558	165	16	0	0	0	0	17025.$	
HR	31	31	31	31	31	30	30	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31		742

FLAGS:
- QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
- BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
- ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
  OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH)   YEAR 1980   MONTH 6

ULTRAVIOLET KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	HOUR 13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
[illegible]	0	0	0	0	0	0	10	37	67	107	136	153	159	174	138	99	72	40	14	1	0	0	0	0	1208.	24
[illegible]	0	0	0	0	0	0	10	35	68	102	133	154	150	154	133	99	63	34	13	1	0	0	0	0	1149.	24
[illegible]	0	0	0	0	0	0	2	9	8	43	76	137	121	119	72%	82	35%	25%	5	1	0	0	0	0	735.	24
[illegible]	0	0	0	0	0	0	10	30	54	84	120	138	130	119	89	50	45	13	3	0	0	0	0	0	886.	24
[illegible]	0	0	0	0	0	0	17$	33	61	89	109	132	143	142	91	66	51	33	6	0	0	0	0	0	973.	24
[illegible]	0	0	0	0	0	0	10	33	62	98	124	141	143	130	112	93	66	41	16	2	0	0	0	0	1072.	24
[illegible]	0	0	0	0	0	0	12	40	65	101	129	131	136	93	105	64	44	19	6	1	0	0	0	0	946.	24
[illegible]	0	0	0	0	0	0	5	26	36	44	20	49	119	149	138	104	67	42	15	1	0	0	0	-0	816.	24
[illegible]	0	0	0	0	0	0	11	38	71	104	130	151	154	150	128	101	70	42	17	2	0	0	0	0	1167.	24
0	0	0	0	0	0	0	13	40	75	109	141	160	165	159	139	110	75	43	17	2	0	0	0	0	1248.	24
1	0	0	0	0	0	1	13	40	73	108	136	155	162	150	127	97	66	38	11	1	0	0	0	0	1179.	24
2	0	0	0	0	0	9999*	21*	38	54	101	139	147	134	138	90	91	73	28	13	2	0	0	0	0	1059.$	22
3	0	0	0	0	0	0	5	12	27	33	53	70	74	62	66	46	42	24	7	1	0	0	0	0	523.	24
4	0	0	0	0	0	0	9	22	40	39	12	18	69	56	33	29	21	12	5	1	0	0	0	0	366.	24
5	0	0	0	0	0	0	11	37	68	89	78	114	132	135	127	89	58	40	19	2	0	0	0	0	999.	24
6	0	0	0	0	0	0	5	11	22	54	71	70	95	75	67	43	40	24	9	0	0	0	0	0	587.	24
7	0	0	0	0	0	0	1	4	6	17	20	31	20	14	19	48	51	14	4	1	0	0	0	0	250.	24
8	0	0	0	0	0	3$	6	12	28	95	122	148	169	133	136	118	65%	45	20	3	0	0	0	0	1102.	24
9	0	0	0	0	0	0	9	31	31	47	53	58	60	39	25	36	23	9	11	1	0	0	0	0	432.	24
0	0	0	0	0	0	0	1	5	12	38	76	87	76	106	118	106	71	49	20	3	0	0	0	0	768.	24
1	0	0	0	0	0	1	15	43	77	108	136	144	161	152	120	110	74	40	16	2	0	0	0	0	1200.	24
2	0	0	0	0	0	0	7	14	23	19	21	50	62	66	53	62	33	10	3	1	0	0	0	0	423.	24
3	0	0	0	0	0	0	12	28	53	40	39	50	86	32	6	17	27	51	17	1	0	0	0	0	460.	24
4	0	0	0	0	0	0	11	43	75	98	132	136	128	128	117	94	73	44	18	3	0	0	0	0	1099.	24
5	0	0	0	0	0	1	14	40	71	100	128	128	131	121	111	110	80	47	20	3	0	0	0	0	1104.	24
6	0	0	0	0	0	1	13	36	64	95	121	133	119	142	126	93	72	43	19	3	0	0	0	0	1078.	24
7	0	0	0	0	0	1	10	26	32	48	99	131	129	117	93	90	62	40	19	3	0	0	0	0	901.	24
8	0	0	0	0	0	1	15	36	50	73	98	101	105	120	42	17	19	19	16	3	0	0	0	0	715.	24
9	0	0	0	0	0	1	14	38	65	91	92	135	122	93	106	88	57	35	17	3	0	0	0	0	957.	24
0	0	0	0	0	0	1	19$	36	69	100	123	144	144	144	119	107	68	37	19	3	0	0	0	0	1132.	24
1	0	0	0	0	0	2	16	41	74	107	98	90	90	128	109	72	36%	18%	10	2	0	0	0	0	892.	24
V	0	0	0	0	0	1$	10$	29	51	77	96	112	119	114	95	78	55	32	13	2	0	0	0	0	885.$	
R	31	31	31	31	31	30	30	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31		742

.AGS:
- QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
- BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
- ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
  OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 5

AVAILABLE SUNSHINE %

DAY	HOUR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVG	HR
1	0	0	0	0	0	0	44	92	83	100	99	88	97	99	92	85	87	97	42	0	0	0	0	0	82.	24
2	0	0	0	0	0	0	15	100	100	100	100	98	83	99	95	81	60	28	11	0	0	0	0	0	72.	24
3	0	0	0	0	0	0	0	0	0	0	6	80	44	62	31	60	18	16	0	0	0	0	0	0	23.	24
4	0	0	0	0	0	0	0	24	15	54	100	100	75	65	36	7	1	0	0	0	0	0	0	0	35.	24
5	0	0	0	0	0	0	0	99	100	100	100	100	97	100	48	27	45	38	0	0	0	0	0	0	64.	24
6	0	0	0	0	0	0	38	93	100	100	100	97	90	79	78	82	86	100	73	0	0	0	0	0	82.	24
7	0	0	0	0	0	0	56	100	100	100	100	74	76	37	47	4	0	0	0	0	0	0	0	0	51.	24
8	0	0	0	0	0	0	0	5	3	0	0	0	40	97	99	82	67	92	17	0	0	0	0	0	37.	24
9	0	0	0	0	0	0	1	86	100	100	96	95	90	97	100	100	100	100	100	6	0	0	0	0	86.	24
10	0	0	0	0	0	0	76	100	100	100	100	100	100	100	100	100	100	100	96	0	0	0	0	0	93.	24
11	0	0	0	0	0	0	75	100	100	100	100	100	100	100	100	99	100	50	0	0	0	0	0	0	82.	24
12	0	0	0	0	0	0	0	65	15	86	100	100	66	88	28	49	91	0	0	0	0	0	0	0	55.	24
13	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0.	24
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	24
15	0	0	0	0	0	0	0	0	61	55	2	24	47	59	95	53	6	26	52	0	0	0	0	0	35.	24
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	24
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0.	24
18	0	0	0	0	0	0	0	0	0	31	67	72	88	64	86	100	39	68	54	0	0	0	0	0	48.	24
19	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0.	24
20	0	0	0	0	0	0	0	0	0	0	3	6	0	18	49	65	55	98	74	0	0	0	0	0	26.	24
21	0	0	0	0	0	0	55	100	100	100	100	100	97	89	75	100	95	72	4	0	0	0	0	0	78.	24
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.	24
23	0	0	0	0	0	0	0	4	20	0	0	0	1	0	0	0	0	73	3	0	0	0	0	0	7.	24
24	0	0	0	0	0	0	7	60	69	59	82	67	57	68	54	48	79	60	0	0	0	0	0	0	51.	24
25	0	0	0	0	0	0	0	53	76	73	83	61	51	51	51	92	97	59	5	0	0	0	0	0	54.	24
26	0	0	0	0	0	0	0	69	99	100	100	95	63	90	89	72	93	100	42	0	0	0	0	0	72.	24
27	0	0	0	0	0	0	0	0	5	1	56	85	59	53	37	76	70	96	30	0	0	0	0	0	40.	24
28	0	0	0	0	0	0	0	37	5	30	24	12	18	76	0	0	0	0	0	0	0	0	0	0	14.	24
29	0	0	0	0	0	0	0	86	100	78	26	91	73	44	75	82	36	11	0	0	0	0	0	0	50.	24
30	0	0	0	0	0	0	0	75	100	100	100	94	84	93	90	99	99	52	9	0	0	0	0	0	72.	24
31	0	0	0	0	0	0	39	100	100	97	52	25	25	87	72	45	29	41	0	0	0	0	0	0	50.	24
AV	0	0	0	0	0	0	14	47	50	54	55	57	52	59	52	52	47	44	20	0	0	0	0	0	44.	
HR	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31		744

FLAGS:

% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS

* - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS

$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH)   YEAR 1980   MONTH 6

DIRECT NORMAL KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	4	400	1427	2041	2384	2138	1176	1350	1490	982	1323	1451	582	849	132	0	0	0	0	17728.	24
2	0	0	0	0	0	33	518	1517	2068	2361	2406	2102	1484	1818	1135	1897	1419	1373	758	80	0	0	0	0	20967.	24
3	0	0	0	0	0	24	813	1711	2193	2257	2264	1507	1632	1945	2515	2240	2231	1755	1045	169	0	0	0	0	24301.	24
4	0	0	0	0	0	1	602	1412	2013	2470	2869	2974	2886	2716	1743*	804*	797*	779*	762*	581*	0	0	0	0	99999.*	18
5	0	0	0	0	0	9999*	417*	423*	459*	1178*	2757	2871	2986	2954	2876	788	561	31	152	95	0	0	0	0	99999.*	19
6	0	0	0	0	0	2	3	3	3	34	216	711	701	911	291	387	595	420	53%	2	0	0	0	0	4332.	24
7	0	0	0	0	0	12	372	778	1035	1440	1760	1618	1365	2045	2172	1369	843	863	245	41	0	0	0	0	15956.	24
8	0	0	0	0	0	2	3	48	415	896	904	725	1148	1670	1108	394	14	444	415	8	0	0	0	0	8194.	24
9	0	0	0	0	0	64	264	1324	2478	1625	519	76	29	3	54	1934	2827	2476	697	274	0	0	0	0	14642.	24
10	0	0	0	0	0	258	1748	2550	2911	3173	3291	3311	3303	3234	3147	3007	2708	2328	1670	376	0	0	0	0	37015.	24
11	0	0	0	0	0	77	965$	1853	2238	2439	2678	2283	1536	1874	2174	2057	1613	1682	1061	266	0	0	0	0	24797.	24
12	0	0	0	0	0	2	1203	1962	2370	2633	2782	2699	1904	1123	890	887	1178	295	73	34	0	0	0	0	20034.	24
13	0	0	0	0	0	16	514	1131	1662	1957	1448	1517	859	255	937	642	176	256	604	67	0	0	0	0	12043.	24
14	0	0	0	0	0	35	380	380	470	1974	2076	1682	1007	1145	1422	1664	1570	1186	769	146	0	0	0	0	15905.	24
15	0	0	0	0	0	57	857	1654	2038	2263	2338	2170	1779	1643	1518	1454	851	1310	693	76	0	0	0	0	20701.	24
16	0	0	0	0	0	17	387	1167	1343	2373	1959	1816	1299	1470	1546	1094	596	288	2	2	0	0	0	0	15361.	24
17	0	0	0	0	0	1	69$	137	445	304	3	3	43	82	313	6	3	51	44	2	0	0	0	0	1505.	24
18	0	0	0	0	0	29%	91	95	239	108	73$	37	329*	227*	682*	2057*	1951*	634*	856*	203*	0	0	0	0	99999.*	16
19	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	3*	9999*	0	0	0	0	99999.*	9
20	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	1163*	863*	234*	0	0	0	0	99999.*	9
21	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
22	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
23	0	0	0	0	0	9999*	3*	3	3	3	20	140	666	1334	1113	2	2	3	4	3	0	0	0	0	3420.$	22
24	0	0	0	0	0	1	3	14	3	105	996	469	483	215	209	472	15	3	3	4	0	0	0	0	2994.	24
25	0	0	0	0	0	1	4	3	3	3	75	613	264	427	1177	431	347	158	56	98	0	0	0	0	3660.	24
26	0	0	0	0	0	128	1244	2005	2605	2910	3020	2508	1736	1629$	1521%	553	1239	1219	688	283	0	0	0	0	23288.	24
27	0	0	0	0	0	126	1227	2042	2424	2338	2007	1796	1707	1383	671	479	692	1227	821%	96%	0	0	0	0	19036.	24
28	0	0	0	0	0	22	538	1057	2049	2110	2524	2191	2042	1926	2006	2517	2478	2117	1430	343	0	0	0	0	25351.	24
29	0	0	0	0	0	1	14	458$	901	994	1480	113	325	245	3	3	1268	991	46	2	0	0	0	0	6845.	24
30	0	0	0	0	0	67	1012	1792	2401	2504	2648	2706	2896	2808	2767	2986	2881	2503	1864	508	0	0	0	0	32342.	24
AV	0	0	0	0	0	41$	551$	1061$	1454$	1666$	1740$	1531$	1417$	1454$	1356$	1191$	1148$	982$	585$	130$	0	0	0	0	16308.$	
HR	30	30	30	30	30	24	24	25	25	25	26	26	25	25	24	24	24	24	24	24	30	30	30	30		639

FLAGS:

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OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH)   YEAR 1980   MONTH 6

DIRECT (RG630) KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	9	328	1056	1399	1566	1384	761	887	988	656	900	1025	447	730	140	0	0	0	0	12277.	24
2	0	0	0	0	0	36	425	1121	1426	1572	1563	1380	1021	1256	755	1288	1012	1055	666	93	0	0	0	0	14668.	24
3	0	0	0	0	0	29	706	1255	1498	1517	1490	986	1059	1266	1643	1501	1534	1313	904	177	0	0	0	0	16880.	24
4	0	0	0	0	0	3	515	1064	1378	1600	1787	1839	1795	1725	1337*	585*	580*	580*	582*	497*	0	0	0	0	99999.*	18
5	0	0	0	0	0	9999*	454*	463*	502*	893*	1721	1781	1854	1840	1811	513	395	29	140	98	0	0	0	0	99999.*	19
6	0	0	0	0	0	4	7	6	6	30	168	542	520	680	244	329	515	397	72	6	0	0	0	0	3527.	24
7	0	0	0	0	0	14	331	587	757	1026	1237	1094	929	1396	1476	974	654	724	251	56	0	0	0	0	11506.	24
8	0	0	0	0	0	3	6	35	279	592	577	460	768	1116	741	259	14	325	329	12	0	0	0	0	5517.	24
9	0	0	0	0	0	61	181	854	1551	998	296	38	19	6	33	1182	1782	1644	512	236	0	0	0	0	9392.	24
10	0	0	0	0	0	225	1364	1780	1933	2047	2090	2095	2085	2044	2003	1938	1817	1641	1297	350	0	0	0	0	24710.	24
11	0	0	0	0	0	78	747$	1417	1608	1711	1819	1529	1029	1254	1460	1407	1165	1324	950	267	0	0	0	0	17765.	24
12	0	0	0	0	0	3	1001	1469	1665	1784	1852	1791	1273	776	638	638	900	256	74	42	0	0	0	0	14164.	24
13	0	0	0	0	0	20	495	978	1310	1438	1041	1097	627	193	696	495	158	248	596	78	0	0	0	0	9470.	24
14	0	0	0	0	0	37	366	348	388	1459	1463	1182	723	814	1086	1266	1242	1016	719	157	0	0	0	0	12267.	24
15	0	0	0	0	0	62	765	1293	1491	1595	1625	1494	1222	1149	1080	1050	649	1075	647	89	0	0	0	0	15286.	24
16	0	0	0	0	0	21	329	888	938	1598	1274	1184	850	969	1041	766	430	222	6	5	0	0	0	0	10521.	24
17	0	0	0	0	0	3	46$	89	295	201	6	6	29	59	218	8	6	45	42	5	0	0	0	0	1057.	24
18	0	0	0	0	0	3	24	28	163	73	51$	29	231*	166*	499*	1412*	1369*	499*	740*	196*	0	0	0	0	99999.*	16
19	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	6*	9999*	0	0	0	0	99999.*	9
20	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	867*	709*	217*	0	0	0	0	99999.*	9
21	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
22	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
23	0	0	0	0	0	9999*	6*	6	6	6	17	92	441	880	739	6	6	6	6	5	0	0	0	0	2315.$	22
24	0	0	0	0	0	3	6	13	6	65	644	304	297	145	224$	303	13	6	6	7	0	0	0	0	2041.	24
25	0	0	0	0	0	3	6	6	6	6	48	404	166	267	741	279	231	125	51	105	0	0	0	0	2444.	24
26	0	0	0	0	0	119	987	1425	1711	1853	1873	1543	1044	1010$	975%	365	835	863	579	262	0	0	0	0	15444.	24
27	0	0	0	0	0	129	1010	1457	1641	1577	1334	1190	1160	986	501	359	531	991	774%	119%	0	0	0	0	13757.	24
28	0	0	0	0	0	27	506	859	1460	1422	1667	1438	1393	1361	1410	1699	1678	1507	1138	321	0	0	0	0	17887.	24
29	0	0	0	0	0	3	12	327$	643	645	956	64	222	170	6	5	825	680	46	5	0	0	0	0	4609.	24
30	0	0	0	0	0	23	831	1302	1604	1690	1788	1770	1880	1839	1824	1942	1913	1755	1458	479	0	0	0	0	22098.	24
AV	0	0	0	0	0	38$	458$	787$	1006$	1123$	1145$	1004$	932$	968$	917$	811$	805$	737$	500$	130$	0	0	0	0	11360.$	
HR	30	30	30	30	30	24	24	25	25	25	26	26	25	25	24	24	24	24	24	24	30	30	30	30		639

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OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 6

GLOBAL HORIZ. KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	6	273	967	1728	2425	2809	2346	2666	2736	1994	2172	1825	880	573	64	0	0	0	0	23465.	24
2	0	0	0	0	0	23	313	996	1726	2392	2883	3232	2911	3294	2309	2602	1586	1162	530	42	0	0	0	0	26001.	24
3	0	0	0	0	0	10	341	1019	1727	2356	2909	2735	2933	3114	3165	2523	1925	1172	469	39	0	0	0	0	26436.	24
4	0	0	0	0	0	3	319	975	1714	2431	3062	3433	3538	3429	2017*	651*	636*	758*	772*	592*	0	0	0	0	99999.*	18
5	0	0	0	0	0	9999*	425*	434*	469*	1313*	2982	3339	3520	3420	3163	1679	1205	549	282	49%	0	0	0	0	99999.*	19
6	0	0	0	0	0	4	90	311	444	1002	1770	2541	2418	2417	1509	1782	1606	865	259	37%	0	0	0	0	17055.	24
7	0	0	0	0	0	22	361	782	1392	2158	2812	3007	2688	3206	3053	2355	1421	1079	380	47%	0	0	0	0	24763.	24
8	0	0	0	0	0	8	221	562	1187	1985	2166	2206	2779	2937	2384	1734	1005	957	445	37	0	0	0	0	20613.	24
9	0	0	0	0	0	19	308	1033	1847	1966	1934	1891	1465	1076	1752	2492	2086	1360	447	89	0	0	0	0	19765.	24
10	0	0	0	0	0	23	435	1146	1891	2617	3174	3529	3670	3555	3238	2723	2032	1295	561	58%	0	0	0	0	29946.	24
11	0	0	0	0	0	18	524$	1029	1713	2351	2948	2977	2651	2740	2791	2355	1675	1232	488	65%	0	0	0	0	25558.	24
12	0	0	0	0	0	20	388	1063	1794	2479	3031	3275	2885	2352	1810	1634	1406	625	249	49%	0	0	0	0	23061.	24
13	0	0	0	0	0	15	325	939	1652	2336	2576	2881	2370	1592	2147	1551	737	590	461	44%	0	0	0	0	20214.	24
14	0	0	0	0	0	15	335	710	1095	2299	2811	2776	2254	2244	2618	2368	1793	1087	464	51%	0	0	0	0	22920.	24
15	0	0	0	0	0	15	339	985	1679	2352	2885	3154	2974	2894	2629	2147	1367	1174	461	47%	0	0	0	0	25102.	24
16	0	0	0	0	0	11	260	800	1342	2436	2808	2965	2659	2646	2535	1882	1374	915	200	9%	0	0	0	0	22842.	24
17	0	0	0	0	0	2	273$	543	1262	1267	849	595	1422	1374	1731	396	43%	462	318	37	0	0	0	0	10573.	24
18	0	0	0	0	0	4	180	497	973	1134	1149$	1164	1702*	1479*	1326*	2621*	1894*	891*	531*	74*	0	0	0	0	99999.*	16
19	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	235*	9999*	0	0	0	0	99999.*	9
20	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	860*	531*	79*	0	0	0	0	99999.*	9
21	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
22	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
23	0	0	0	0	0	9999*	39*	294	595	385	1033	1588	2249	2953	2479	605	243	34	16	3	0	0	0	0	12657.$	22
24	0	0	0	0	0	2	105	382	485	921	2338	2191	2522	1285%	1308	1950	541	9	17	15	0	0	0	0	14072.	24
25	0	0	0	0	0	2	95	148	343	558	1182	2124	1868	1814	2155	1434	1199	667	287	63	0	0	0	0	13938.	24
26	0	0	0	0	0	23	413	1008	1771	2423	2987	3357	3136	2810$	2484	1114	1466	1300	456	84%	0	0	0	0	24832.	24
27	0	0	0	0	0	13	341	992	1690	2244	2533	2715	2854	2690	1763	1342	1362	1130	478	46	0	0	0	0	22195.	24
28	0	0	0	0	0	11	308	905	1713	2242	2859	2966	3266	3221	3044	2772	2106	1344	628	72%	0	0	0	0	27457.	24
29	0	0	0	0	0	9	222	832$	1441	2010	2753	2198	2111	1419%	789	691	1886	1054	309	30	0	0	0	0	17752.	24
30	0	0	0	0	0	15	400	1041	1731	2392	2996	3262	3557	3542	3185	2794	2154	1391	642	81%	0	0	0	0	29183.	24
AV	0	0	0	0	0	12$	299$	798$	1397$	1966$	2471$	2633$	2695$	2590$	2335$	1879$	1418$	930$	393$	48$	0	0	0	0	21865.$	
HR	30	30	30	30	30	24	24	25	25	25	26	26	25	25	24	24	24	24	24	24	30	30	30	30		639

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OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 6

GLOBAL (RG630) KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	2	142	565	998	1404	1617	1312%	1505%	1533%	1088%	1222%	1043	479	309	25	0	0	0	0	13244.	24
2	0	0	0	0	0	9	170	587	1015	1397	1666	1865	1657%	1919	1297%	1491	881%	656	295	13	0	0	0	0	14918.	24
3	0	0	0	0	0	3	192	606	1015	1373	1685	1552%	1669	1767%	1806	1427	1084	655	240	9	0	0	0	0	15083.	24
4	0	0	0	0	0	2	177	575	1004	1414	1762	1968	2024	1951	1820*	9999*	9999*	9999*	753*	579*	0	0	0	0	99999.*	18
5	0	0	0	0	0	9999*	414*	421*	457*	980*	1725	1927	2031	1971	1823	937	669	278	130	21	0	0	0	0	99999.*	19
6	0	0	0	0	0	3	28	149	219	546	994	1497	1357	1381	846	1009	920	477	112	10	0	0	0	0	9549.	24
7	0	0	0	0	0	6	195	434	798	1241	1634	1715	1503%	1889	1725	1327	784	599	180	8	0	0	0	0	14037.	24
8	0	0	0	0	0	2	97	291	652	1116	1205	1208	1553	1651	1333	953	539	522	220	7	0	0	0	0	11347.	24
9	0	0	0	0	0	6	160	609	1098	1138	1094	1073	815	579	985	1426	1190	776	226	41	0	0	0	0	11216.	24
10	0	0	0	0	0	8	259	692	1124	1541	1859	2059	2136	2060	1867	1559	1167	735	298	17	0	0	0	0	17380.	24
11	0	0	0	0	0	5	312$	619	1030	1404	1734	1725	1531%	1611%	1695%	1334%	934%	709	260	20	0	0	0	0	14924.	24
12	0	0	0	0	0	6	223	635	1057	1453	1764	1893	1763%	1338%	1121*	1032*	809%	296%	79	16	0	0	0	0	14077.$	22
13	0	0	0	0	0	4	179	560	980	1371	1507	1676	1339%	862%	1252%	881%	375%	314	248	11	0	0	0	0	11557.	24
14	0	0	0	0	0	3	190	404	617%	1354	1630	1625%	1282%	1282%	1511	1439	1034	613	237	12	0	0	0	0	13232.	24
15	0	0	0	0	0	4	187	587	993	1374	1674	1871	1706%	1645%	1491%	1215%	759%	668	233	9	0	0	0	0	14416.	24
16	0	0	0	0	0	2	125	451	765	1402	1601	1680	1485%	1477%	1423%	1067%	744%	488	75	3	0	0	0	0	12787.	24
17	0	0	0	0	0	2	144$	285	719	701	437	287	766	722%	1082*	4*	4	4*	4*	3	0	0	0	0	99999.*	20
18	0	0	0	0	0	2	4*	9999*	868*	910*	993*	1014*	1435*	1333*	698*	1299*	893*	567*	4*	4*	0	0	0	0	99999.*	10
19	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	137*	9999*	0	0	0	0	99999.*	9
20	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	518*	321*	48*	0	0	0	0	99999.*	9
21	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
22	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
23	0	0	0	0	0	9999*	29*	166	320	202	567	890	1265	1690	1404	321	121	16	9	3	0	0	0	0	7074.$	22
24	0	0	0	0	0	4	65	217	278	529	1372	1261	1432	718	714	1137	303	5	9	17	0	0	0	0	8060.	24
25	0	0	0	0	0	3	62	78	179	301	684	1236	1058	1036	1232	814	684	379	169	43	0	0	0	0	7959.	24
26	0	0	0	0	0	22	238	619	1058	1434	1745	1949	1801	1620$	1439	639	852	760	271	51	0	0	0	0	14500.	24
27	0	0	0	0	0	11	229	623	1024	1351	1487	1590	1669	1604	1039	766%	765%	659	282	24	0	0	0	0	13124.	24
28	0	0	0	0	0	9	195	563	1032	1318	1671	1710	1911	1883	1772	1608	1219	785	375	41	0	0	0	0	16092.	24
29	0	0	0	0	0	8	137	493$	848	1174	1597	1240	1194	789	429	379	1091	601	178	19	0	0	0	0	10177.	24
30	0	0	0	0	0	12	248	633	1059	1430	1773	1909	2069	2060	1853	1622	1260	824	386	47	0	0	0	0	17186.	24
AV	0	0	0	0	0	6$	172$	477$	828$	1165$	1459$	1549$	1541$	1481$	1365$	1117$	801$	534$	210$	20$	0	0	0	0	12725.$	
HR	30	30	30	30	30	24	23	24	24	24	25	25	25	25	22	22	24	23	23	24	30	30	30	30		627

FLAGS:
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OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 6

DIFFUSE HORIZ. KJ/M2

DAY	HOUR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	0	169	401	542	654	938	1202	1309	1269	1095	1140	929	630	397	52	0	0	0	0	10727.	24
2	0	0	0	0	0	0	200	400	541	642	788	1210	1436	1527	1293	1124	730	585	366	35	0	0	0	0	10877.	24
3	0	0	0	0	0	0	163	347	462	681	910	1264	1291	1195	885	766	542	407	230	19	0	0	0	0	9161.	24
4	0	0	0	0	0	0	188	416	543	585	543	572	661	775	805*	9999*	9999*	9999*	726*	9999*	0	0	0	0	99999.*	18
5	0	0	0	0	0	9999*	380*	385*	9999*	719*	571	576	555	557	586	1028	873	554	263	34	0	0	0	0	99999.*	19
6	0	0	0	0	0	0	89	307	439	958	1550	1839	1710	1531	1273	1477	1239	703	267	38	0	0	0	0	13420.	24
7	0	0	0	0	0	1	289	452	808	1054	1278	1443	1335	1199	1082	1270	902	706	343	54	0	0	0	0	12215.	24
8	0	0	0	0	0	0	224	536	911	1295	1352	1491	1612	1299	1358	1385	990	764	335	31	0	0	0	0	13583.	24
9	0	0	0	0	0	0	222	486	388	781	1442	1766	1413	1063	1665	953	312	259	269	47	0	0	0	0	11066.	24
10	0	0	0	0	0	0	83	148	208	255	288	332	367	381	381	358	340	272	162	17	0	0	0	0	3590.	24
11	0	0	0	0	0	0	149$	297	429	548	614	798	1113	905	799	730	633	480	236	36	0	0	0	0	7767.	24
12	0	0	0	0	0	0	135	296	430	536	599	683	992	1244	1011	907	708	508	250	43	0	0	0	0	8342.	24
13	0	0	0	0	0	0	212	492	692	871	1291	1396	1497	1331	1301	1025	646	505	321	38	0	0	0	0	11620.	24
14	0	0	0	0	0	0	249	575	804	841	1003	1172	1250	1118	1342	1065	819	578	292	38	0	0	0	0	11146.	24
15	0	0	0	0	0	0	164	348	518	683	853	1080	1196	1282	1254	1016	840	603	302	47	0	0	0	0	10186.	24
16	0	0	0	0	0	0	166	362	529	675	1080	1215	1348	1194	1138	1001	988	779	223	0	0	0	0	0	10697.	24
17	0	0	0	0	0	0	233$	466	985	1051	844	593	1350	1280	1425	403	50	434	296	22	0	0	0	0	9432.	24
18	0	0	0	0	0	0	167	470	812	1026	1066$	1106	1348*	1240*	671*	943*	660*	592*	309*	37*	0	0	0	0	99999.*	16
19	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	238*	9999*	0	0	0	0	99999.*	9
20	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	464*	333*	56*	0	0	0	0	99999.*	9
21	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
22	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
23	0	0	0	0	0	9999*	34*	284	582	375	991	1419	1553	1608	1432	619	253	38	0	0	0	0	0	0	9315.$	22
24	0	0	0	0	0	0	104	367	476	820	1416	1706	1998	1078	1088	1530	530	13	17	0	0	0	0	0	11142.	24
25	0	0	0	0	0	0	90	146	334	543	1090	1510	1569	1378	1031	1063	958	585	277	50	0	0	0	0	10622.	24
26	0	0	0	0	0	0	127	252	285	281	366	948	1402	1256$	1110	668	685	717	306	59	0	0	0	0	8463.	24
27	0	0	0	0	0	0	111	219	324	538	795	998	1156	1334	1168	984	946	613	274	41	0	0	0	0	9502.	24
28	0	0	0	0	0	0	204	482	550	692	682	886	1241	1335	1238	796	552	407	290	47	0	0	0	0	9402.	24
29	0	0	0	0	0	0	210	566$	922	1234	1449	2043	1752	1164	778	683	1042	540	296	19	0	0	0	0	12699.	24
30	0	0	0	0	0	0	161	308	374	557	699	663	660	772	660	408	314	249	169	29	0	0	0	0	6023.	24
AV	0	0	0	0	0	0$	171$	377$	555$	727$	942$	1150$	1271$	1163$	1100$	933$	701$	497$	258$	33$	0	0	0	0	9879.$	
HR	30	30	30	30	30	24	24	25	25	25	26	26	25	25	24	24	24	24	24	24	30	30	30	30		639

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OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 6

LAT. TILTED KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	10	158	644	1348	2077	2524	2145	2462	2515	1790	1864	1452	655	332	48	0	0	0	0	20025.	24
2	0	0	0	0	0	22	176	641	1350	2050	2625	2994	2730	3045	2094	2285	1289	822	322	33	0	0	0	0	22479.	24
3	0	0	0	0	0	12	154	643	1350	2025	2636	2534	2718	2884	2860	2203	1542	786	227	25	0	0	0	0	22599.	24
4	0	0	0	0	0	9	165	633	1346	2086	2766	3169	3298	3188	1860*	597*	594*	599*	690*	581*	0	0	0	0	99999.*	18
5	0	0	0	0	0	9999*	421*	427*	463*	1182*	2691	3088	3283	3168	2887	1497	1018	481	221	43	0	0	0	0	99999.*	19
6	0	0	0	0	0	12	101	291	402	890	1563	2318	2234	2215	1311	1576	1353	677	209	41	0	0	0	0	15194.	24
7	0	0	0	0	0	25	237	564	1124	1881	2531	2753	2495	2983	2770	2060	1190	823	281	44	0	0	0	0	21761.	24
8	0	0	0	0	0	17	209	489	993	1726	1976	2025	2567	2708	2137	1527	876	755	301	40	0	0	0	0	18347.	24
9	0	0	0	0	0	22	197	687	1452	1722	1728	1757	1352	909	1569	2239	1656	873	269	64	0	0	0	0	16496.	24
10	0	0	0	0	0	18	138	663	1440	2190	2810	3215	3384	3267	2907	2327	1602	834	224	32	0	0	0	0	25052.	24
11	0	0	0	0	0	18	334$	650	1333	1992	2632	2729	2443	2552	2515	2055	1369	853	252	46	0	0	0	0	21774.	24
12	0	0	0	0	0	19	171	662	1402	2121	2726	3021	2693	2167	1651	1445	1154	510	214	50	0	0	0	0	20007.	24
13	0	0	0	0	0	21	209	654	1320	1995	2290	2659	2192	1468	1912	1436	663	511	291	39	0	0	0	0	17661.	24
14	0	0	0	0	0	21	238	553	926	1980	2518	2532	2068	2092	2393	2065	1450	780	273	41	0	0	0	0	19930.	24
15	0	0	0	0	0	19	172	626	1314	2014	2591	2897	2760	2667	2347	1842	1134	839	286	45	0	0	0	0	21554.	24
16	0	0	0	0	0	17	156	494	1062	2080	2522	2706	2455	2432	2269	1666	1120	738	206	24	0	0	0	0	19947.	24
17	0	0	0	0	0	9	231$	452	1058	1076	824	589	1348	1291	1575	365	47	371	251	39	0	0	0	0	9526.	24
18	0	0	0	0	0	10	139	414	812	991	1035$	1079	1583*	1418*	1027*	2185*	1510*	699*	304*	50*	0	0	0	0	99999.*	16
19	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	191*	9999*	0	0	0	0	99999.*	9
20	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	538*	302*	57*	0	0	0	0	99999.*	9
21	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
22	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
23	0	0	0	0	0	9999*	56*	272	531	353	947	1395	2053	2665	2250	543	196	43	26	15	0	0	0	0	11403.$	22
24	0	0	0	0	0	9	102	311	438	812	2089	1985	2287	1160	1150	1685	451	20	26	22	0	0	0	0	12546.	24
25	0	0	0	0	0	9	80	135	293	494	1067	1903	1671	1650	1945	1265	1015	563	238	50	0	0	0	0	12378.	24
26	0	0	0	0	0	17	155	571	1338	2032	2645	3024	2912	2570$	2227	998	1143	937	295	48	0	0	0	0	20912.	24
27	0	0	0	0	0	12	127	581	1288	1894	2241	2500	2637	2455	1596	1190	1140	804	276	41	0	0	0	0	18783.	24
28	0	0	0	0	0	13	175	607	1322	1900	2543	2751	3031	2957	2709	2364	1673	886	308	40	0	0	0	0	23279.	24
29	0	0	0	0	0	14	193	659$	1125	1727	2394	1952	1881	1278	712	629	1533	783	251	40	0	0	0	0	15170.	24
30	0	0	0	0	0	13	174	651	1333	2010	2666	2983	3285	3229	2874	2401	1700	905	258	38	0	0	0	0	24520.	24
AV	0	0	0	0	0	15$	175$	542$	1108$	1685$	2215$	2412$	2490$	2381$	2102$	1647$	1157$	677$	243$	39$	0	0	0	0	18887.$	
HR	30	30	30	30	30	24	24	25	25	25	26	26	25	25	24	24	24	24	24	24	30	30	30	30		639

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ATLANTA (GA TECH)   YEAR 1980   MONTH 6

ULTRAVIOLET KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	1	16	43	78	113	132	120	131	134	106	98	73	40	24	5	0	0	0	0	1115.	24
2	0	0	0	0	0	2	16	44	77	110	137	152	142	144	111	112	72	47	20	4	0	0	0	0	1189.	24
3	0	0	0	0	0	2	17	44	76	107	136	135	144	149	142	112	83	49	22	5	0	0	0	0	1223.	24
4	0	0	0	0	0	2	17	43	76	110	143	162	167	160	127*	75*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	18
5	0	0	0	0	0	9999*	50*	51*	55*	85*	141	158	164	155	139	79	55	30	16	4	0	0	0	0	99999.*	19
6	0	0	0	0	0	1	7	19	26	53	89	114	118	110	73	80	68	39	15	4	0	0	0	0	815.	24
7	0	0	0	0	0	2	17	39	66	101	125	141	134	150	139	106	66	47	21	4	0	0	0	0	1159.	24
8	0	0	0	0	0	2	14	31	61	97	109	116	137	140	113	86	54	45	23	4	0	0	0	0	1032.	24
9	0	0	0	0	0	2	18	48	86	100	107	104	81	62	93	116	91	55	22	5	0	0	0	0	991.	24
10	0	0	0	0	0	2	19	49	85	123	153	171	178	169	150	121	84	51	23	5	0	0	0	0	1383.	24
11	0	0	0	0	0	2	22$	43	72	99	130	139	130	136	132	107	77	48	21	5	0	0	0	0	1163.	24
12	0	0	0	0	0	2	17	45	79	113	141	155	140	115	95	85	68	38	20	4	0	0	0	0	1119.	24
13	0	0	0	0	0	2	16	40	71	105	118	134	118	89	96	70	41	29	19	4	0	0	0	0	952.	24
14	0	0	0	0	0	2	14	33	56	102	128	127	107	104	115	100	74	45	21	5	0	0	0	0	1033.	24
15	0	0	0	0	0	2	16	42	73	105	131	144	142	134	119	95	65	47	22	5	0	0	0	0	1141.	24
16	0	0	0	0	0	2	15	39	66	112	133	143	132	130	121	92	66	43	14	2	0	0	0	0	1112.	24
17	0	0	0	0	0	1	15$	30	61	65	51	38	83	74	87	27	7	27	18	4	0	0	0	0	590.	24
18	0	0	0	0	0	2	14	29	53	64	68$	71	92*	80*	66*	124*	86*	46*	26*	6*	0	0	0	0	99999.*	16
19	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	17*	9999*	0	0	0	0	99999.*	9
20	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	38*	24*	6*	0	0	0	0	99999.*	9
21	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
22	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
23	0	0	0	0	0	9999*	6*	20	38	29	64	90	123	149	126	40	20	6	3	0	0	0	0	0	718.$	22
24	0	0	0	0	0	1	11	28	34	59	125	118	135	73	76	102	35	4	4	1	0	0	0	0	806.	24
25	0	0	0	0	0	1	6	13	26	41	73	125	111	107	120	83	64	39	18	5	0	0	0	0	832.	24
26	0	0	0	0	0	2	19	49	85	119	150	168	163	142$	121	62	70	56	23	6	0	0	0	0	1232.	24
27	0	0	0	0	0	2	18	45	77	102	121	131	137	118	82%	70	69	50	24	6	0	0	0	0	1049.	24
28	0	0	0	0	0	2	17	44	80	111	139	149	156	149	137	121	91	57	27	7	0	0	0	0	1285.	24
29	0	0	0	0	0	2	15	44$	74	101	135	120	113	80	52	46	89	53	21	4	0	0	0	0	949.	24
30	0	0	0	0	0	2	17	46	81	111	145	163	178	173	151	129	94	58	28	6	0	0	0	0	1382.	24
AV	0	0	0	0	0	1$	16$	38$	66$	94$	120$	130$	135$	126$	112$	89$	66$	42$	20$	4$	0	0	0	0	1059.$	
HR	30	30	30	30	30	24	24	25	25	25	26	26	25	25	24	24	24	24	24	24	30	30	30	30		639

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    OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH)   YEAR 1980   MONTH 6

AVAILABLE SUNSHINE %

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVG	HR
1	0	0	0	0	0	0	32	97	100	100	91	55	61	67	43	63	83	34	76	0	0	0	0	0	64.	24
2	0	0	0	0	0	0	32	100	100	100	94	87	69	84	49	86	75	93	65	0	0	0	0	0	73.	24
3	0	0	0	0	0	0	67	100	100	98	95	64	67	78	100	96	100	100	95	0	0	0	0	0	82.	24
4	0	0	0	0	0	0	41	100	100	100	100	100	100	100	100	80	70	40	0	0	0	0	0	0	73.	24
5	0	0	0	0	0	0	50	100	100	100	100	100	100	100	100	35	37	0	5	0	0	0	0	0	68.	24
6	0	0	0	0	0	0	0	0	0	1	14	54	42	55	23	23	17	0	0	0	0	0	0	0	16.	24
7	0	0	0	0	0	0	0	43	80	79	91	80	62	90	94	100	69	91	0	0	0	0	0	0	62.	24
8	0	0	0	0	0	0	0	0	27	68	51	37	66	79	70	27	0	26	16	0	0	0	0	0	33.	24
9	0	0	0	0	0	0	13	98	100	60	26	1	1	0	2	79	100	100	46	29	0	0	0	0	46.	24
10	0	0	0	0	0	31	99	100	100	100	100	100	100	100	100	100	100	100	100	41	0	0	0	0	95.	24
11	0	0	0	0	0	0	40	100	100	100	100	83	58	67	78	80	71	95	100	18	0	0	0	0	77.	24
12	0	0	0	0	0	0	94	100	100	100	100	96	72	49	42	41	62	21	3	0	0	0	0	0	62.	24
13	0	0	0	0	0	0	27	100	100	100	99	92	48	17	58	47	14	28	43	0	0	0	0	0	54.	24
14	0	0	0	0	0	0	7	42	34	100	98	74	48	51	80	90	97	98	57	0	0	0	0	0	62.	24
15	0	0	0	0	0	0	60	100	100	100	100	92	75	72	72	70	51	97	53	0	0	0	0	0	73.	24
16	0	0	0	0	0	0	27	81	68	100	100	83	59	61	67	54	36	13	0	0	0	0	0	0	53.	24
17	0	0	0	0	0	0	0	2	27	17	0	0	1	5	20	0	0	0	0	0	0	0	0	0	5.	24
18	0	0	0	0	0	0%	1	2	14	6	10	2	40	10	20	60	40	20	0	0	0	0	0	0	15.	24
19	0	0	0	0	0	0	0	0	20	40	40	50	20	80	40	0	0	0	0	0	0	0	0	0	0.	24
20	0	0	0	0	0	0	0	40	70	60	80	100	100	100	100	60	60	20	0	0	0	0	0	0	1.	24
21	0	0	0	0	0	0	0	0	0	0	0	0	0	80	20	10	0	0	0	0	0	0	0	0	0.	24
22	0	0	0	0	0	0	0	0	10	50	70	70	20	30	20	20	50	10	0	0	0	0	0	0	0.	24
23	0	0	0	0	0	0	0	0	0	0	1	7	33	66	58	0	0	0	0	0	0	0	0	0	12.	24
24	0	0	0	0	0	0	0	1	0	5	48	33	34	12	10	24	0	0	0	0	0	0	0	0	12.	24
25	0	0	0	0	0	0	0	0	0	0	4	31	14	18	43	21	17	9	4	0	0	0	0	0	11.	24
26	0	0	0	0	0	0	89	95	99	100	98	93	82	80	64	22	57	66	49	32	0	0	0	0	71.	24
27	0	0	0	0	0	0	92	100	100	95	79	70	69	64	36	27	41	76	48	0	0	0	0	0	63.	24
28	0	0	0	0	0	0	22	81	100	88	96	83	85	86	88	100	100	100	100	40	0	0	0	0	82.	24
29	0	0	0	0	0	0	0	100	59	70	95	0	17	16	0	0	75	57	0	0	0	0	0	0	34.	24
30	0	0	0	0	0	0	85	100	100	100	100	95	98	98	97	100	100	100	100	50	0	0	0	0	92.	24
AV	0	0	0	0	0	1	34	67	70	73	73	62	58	59	59	55	54	53	36	8	0	0	0	0	54.	
HR	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30		720

FLAGS:

% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
* - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

GT 3% ERROR IN MONTHLY AVG:
DAILY AVG = 51.

ATLANTA (GA TECH)   YEAR 1980   MONTH 7

DIRECT NORMAL KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	153	1495	2378	2767	3006	3163	2877	3131	3021	2848	2527	2456	1845	1487	324	0	0	0	0	33478.	24
2	0	0	0	0	0	3	620	1468	1889	2163	2238	2362	2287	2290	2288	1931	1589	1394	880	139	0	0	0	0	23539.	24
3	0	0	0	0	0	1	2	2	620	1642	1113	1665	2244	2105	2045	1659	1346	538	396	79	0	0	0	0	15457.	24
4	0	0	0	0	0	6	402	936	1048	1049	1444	1330	1801	1516	1270	1557	787	884	342	61	0	0	0	0	14433.	24
5	0	0	0	0	0	1	362$	724	1410	1703	1435	1291	1804	1631	2040	1769	1803	1356	783	120	0	0	0	0	18232.	24
6	0	0	0	0	0	10	293	1179	1813	2095	2318	2492	1910	1733	721	2	2	2	2	2	0	0	0	0	14575.	24
7	0	0	0	0	0	100	1252	2324	2655	2704	2840	2915	2667	2849	2743	2630	2504	2195	1564	346	0	0	0	0	32290.	24
8	0	0	0	0	0	35	795	1645	2073	2320	2566	2670	2614	2619	2554	2400	2035	1578	1039	185	0	0	0	0	27130.	24
9	0	0	0	0	0	1	2*	22*	376*	188	834	1868	1226	567	908	1408	1112	685*	9999*	9999*	0	0	0	0	99999.*	18
10	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
11	0	0	0	0	0	9999*	9999*	9999*	1770*	2023	2310	2307	2059	1698	1308	1246	1321	773	191	16	0	0	0	0	99999.*	20
12	0	0	0	0	0	34	784	1425	1892	2294	2308	2285	2356	2163	1942	1414	819	863	415	41	0	0	0	0	21033.	24
13	0	0	0	0	0	31	941	1854	2368	2573	2704	2831	2854	2757	2629	2363	1878	1400	953	236	0	0	0	0	28374.	24
14	0	0	0	0	0	1	21	597	1203	990	1121	1074	526	1250	971	809	1038	826	484	41	0	0	0	0	10952.	24
15	0	0	0	0	0	1	38	483	1167	1433	1227	318	338	925	1047	894	958	794	408	46	0	0	0	0	10076.	24
16	0	0	0	0	0	2	331	943	1361	1703	1789	1859	2037	2074	1974	1863	1041	814	264	45	0	0	0	0	18100.	24
17	0	0	0	0	0	1	235	1079	1069$	1060	2062	2697	2742	2876	2808	2659	1994	1362	76	2	0	0	0	0	22723.	24
18	0	0	0	0	0	1	272	960	1613	1636	2441	2412	2420	2321	1818	919	833	764	362	70	0	0	0	0	18841.	24
19	0	0	0	0	0	1	273	1187	1640	1777	2079	1276	1546	1668	1908	793	266	100	770	123	0	0	0	0	15407.	24
20	0	0	0	0	0	2	271	50	129	255	558	965	1793	1359	992	2805	2397	2023	1676	189	0	0	0	0	15463.	24
21	0	0	0	0	0	15	6	582	1497	1531	2249	2329	1366	2641	2441	2235	1592	624	979	140	0	0	0	0	20227.	24
22	0	0	0	0	0	1	102	1000	2094	2498	2447	458	624	1232	477	129	7	67	22	2	0	0	0	0	11160.	24
23	0	0	0	0	0	1	3	3	3	351$	700	966	964	1506	2222	94	605	1453	547	45	0	0	0	0	9462.	24
24	0	0	0	0	0	1	3	714	520	3	25	1153	814	1404	976	297	18	281	285	23	0	0	0	0	6516.	24
25	0	0	0	0	0	9999*	9999*	9999*	264*	533	779	1205	1070	2015	1467	2039	1481*	9999*	9999*	9999*	0	0	0	0	99999.*	16
26	0	0	0	0	0	1	449	1305	1939	2284	1924	331	890	2095	1890	497	1604	424	3	2	0	0	0	0	15637.	24
27	0	0	0	0	0	1	51	438	1153	1296	1763	1978	1388	1553	723	96	4	10	3	60	0	0	0	0	10517.	24
28	0	0	0	0	0	1	3	7	3	302$	602	1396$	2190	1226	1459	2101	1695$	1288	421*	35*	0	0	0	0	12768.$	22
29	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
30	0	0	0	0	0	1	466	1348	1909	2279	2459	2615	2674	2653	2213	1199	1908	1280	961	142	0	0	0	0	24106.	24
31	0	0	0	0	0	1	118	968	1358	1591	2109	2149	1830	1826	1423	1040	722	634	449	22	0	0	0	0	16239.	24
AV	0	0	0	0	0	15$	369$	985$	1431$	1562$	1780$	1796$	1799$	1916$	1728$	1427$	1226$	947$	590$	96$	0	0	0	0	17665.$	
HR	31	31	31	31	31	27	26	26	26	29	29	29	29	29	29	29	28	27	26	26	31	31	31	31		694

FLAGS:

% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS

* - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS

$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 7

DIRECT (RG630) KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	154	1213	1694	1856	1972	2034	1839	1997	1906	1830	1765*	1556*	1315	1185	311	0	0	0	0	22681.$	22
2	0	0	0	0	0	5	504	1042	1260$	1479	1522	1588	1536	1539	1545	1360	1174	1094	771	151	0	0	0	0	16570.	24
3	0	0	0	0	0	3	5	5	441	1150	740	1120	1546	1497	1480	1250	1059	449	379	89	0	0	0	0	11212.	24
4	0	0	0	0	0	9	369	742	754	737	1008	930	1237	1043	912	1127	606	745	346	76	0	0	0	0	10641.	24
5	0	0	0	0	0	2	310$	618	1078	1243	1009	903	1253	1126	1407	1231	1308	1081	707	134	0	0	0	0	13412.	24
6	0	0	0	0	0	12	266	908	1285	1432	1541	1619	1266	1170	536	6	5	5	5	5	0	0	0	0	10060.	24
7	0	0	0	0	0	21	939	1572	1720	1748	1819	1854	1733	1829	1777	1727	1676	1539	1219	328	0	0	0	0	21499.	24
8	0	0	0	0	0	38	685	1227	1442	1565	1699	1759	1747	1746	1718	1656	1496	1260	909	195	0	0	0	0	19141.	24
9	0	0	0	0	0	2	5*	24*	309*	138	575	1296	878	451	741	1119	898	580*	9999*	9999*	0	0	0	0	99999.*	18
10	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
11	0	0	0	0	0	9999*	9999*	9999*	1268*	1399	1546	1552	1406	1208	992	991	1030	639	180	28	0	0	0	0	99999.*	20
12	0	0	0	0	0	35	673	1101	1348	1542	1552	1554	1564	1458	1351	1064	672	765	415	57	0	0	0	0	15150.	24
13	0	0	0	0	0	32	757	1287	1524	1607	1679	1728	1740	1700	1641	1528	1301	1075	809	238	0	0	0	0	18647.	24
14	0	0	0	0	0	2	27	485	910	723	807	766	383	907	724	615	833	710	461	54	0	0	0	0	8407.	24
15	0	0	0	0	0	2	39	403	896	1058	888	233	252	680	772	693	786	694	406	64	0	0	0	0	7866.	24
16	0	0	0	0	0	4	298	759	1019	1203	1257	1293	1365	1365	1330	1304	805	726	284	65	0	0	0	0	13076.	24
17	0	0	0	0	0	2	186	806%	754$	702	1301	1649	1660	1715	1695	1641	1355	1068	73	5	0	0	0	0	14612.	24
18	0	0	0	0	0	2	218	646	1024	1049	1669	1660	1666	1602	1277	684	646	668	385	98	0	0	0	0	13295.	24
19	0	0	0	0	0	2	260	959	1192	1202	1400	856	1046	1155	1332	584	211	89	711	142	0	0	0	0	11141.	24
20	0	0	0	0	0	3	229	35	80	153	333	580	1090	833	629	1806	1554	1376	1208	136	0	0	0	0	10047.	24
21	0	0	0	0	0	18	8	383	962	965	1389	1430	839	1617	1504	1405	1038	444	747	126	0	0	0	0	12874.	24
22	0	0	0	0	0	2	90	684	1373	1583	1533	269	366	722	286	71	8	47	22	5	0	0	0	0	7061.	24
23	0	0	0	0	0	2	6	6	6	212$	419	585	608	975	1428	70	453	1178	491	58	0	0	0	0	6495.	24
24	0	0	0	0	0	2	6	629	433	6	22	861	603	1061	762	246	23	294	314	34	0	0	0	0	5296.	24
25	0	0	0	0	0	9999*	9999*	9999*	177*	357	510	777	692	1300	953	1357	1027*	9999*	9999*	9999*	0	0	0	0	99999.*	16
26	0	0	0	0	0	3	427	1073	1434	1603	1321	231	636	1471	1368	378	1249	368	6	4	0	0	0	0	11572.	24
27	0	0	0	0	0	1	53	384	876	977	1290	1414	976	1071	502	75	7	14	6	73	0	0	0	0	7717.	24
28	0	0	0	0	0	1	6	9	6	218$	431	932$	1432	797	992	1463	1259$	1056	386*	49*	0	0	0	0	9051.$	22
29	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
30	0	0	0	0	0	2	452	1121	1438	1623	1707	1781	1811	1797	1540	924	1438	1054	867	156	0	0	0	0	17709.	24
31	0	0	0	0	0	1	126	815	1056	1186	1513	1543	1355	1378	1133	866%	643	602	459	32	0	0	0	0	12709.	24
AV	0	0	0	0	0	13$	313$	746$	1006$	1063$	1190$	1193$	1196$	1280$	1178$	973$	872$	754$	514$	102$	0	0	0	0	12394.$	
HR	31	31	31	31	31	27	26	26	26	29	29	29	29	29	29	28	27	27	26	26	31	31	31	31		692

FLAGS:

% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS

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OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH)   YEAR 1980   MONTH 7

GLOBAL HORIZ. KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	13	372	1063	1810	2506	3110	3321	3568	3441	3111	2580	2031	1266	720	109%	0	0	0	0	29021.	24
2	0	0	0	0	0	2	284	895	1581	2258	2771	3200	3261	3213	2962	2432	1770	1133	487	57	0	0	0	0	26306.	24
3	0	0	0	0	0	3	144	500	1305	2199	2533	2973	3280	3250	2973	2340	1694	825	460	61	0	0	0	0	24541.	24
4	0	0	0	0	0	10	312	852	1634	1951	2458	2663	3232	2900	2500	2389	1381	1034	371	55%	0	0	0	0	23741.	24
5	0	0	0	0	0	4	405$	806	1529	2168	2448	2660	3219	2899	2978	2381	1906	1177	485	52%	0	0	0	0	25118.	24
6	0	0	0	0	0	8	219	873	1596	2266	2824	3254	3109	2950	1907	293%	14	13	10	4	0	0	0	0	19339.	24
7	0	0	0	0	0	18	425	1082	1732	2383	2933	3323	3324	3413	3053	2591	1994	1267	559	62%	0	0	0	0	28160.	24
8	0	0	0	0	0	6	287	918	1616	2281	2872	3244	3410	3340	3053	2581	1922	1188	506	52%	0	0	0	0	27275.	24
9	0	0	0	0	0	4	101*	399*	1193*	1216	2297	3079	2611	2032	2206	2393	1755	1141*	9999*	9999*	0	0	0	0	99999.*	18
10	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
11	0	0	0	0	0	9999*	9999*	9999*	1705*	2217	2817	3152	3172	2965	2631	2341	1714	910	326	42%	0	0	0	0	99999.*	20
12	0	0	0	0	0	7	271	861	1569	2263	2796	3139	3324	3103	2764	2143	1340	1020	428	47%	0	0	0	0	25073.	24
13	0	0	0	0	0	4	279	929	1647	2296	2851	3262	3416	3337	3046	2577	1876	1192	498	52%	0	0	0	0	27263.	24
14	0	0	0	0	0	2	175	747	1471	1953	2532	2716	2154	2892	2379	1815	1648	1016	433	42%	0	0	0	0	21975.	24
15	0	0	0	0	0	3	183	706	1428	2047	2402	1724	1744	2395	2324	1897	1560	1084	389	32	0	0	0	0	19918.	24
16	0	0	0	0	0	2	219	781	1441	2128	2674	3061	3259	3249	3001	2520	1719	1092	454	75%	0	0	0	0	25674.	24
17	0	0	0	0	0	1	170	781	1324$	1867	2818	3267	3385	3363	3101	2637	1835	1103	167%	3	0	0	0	0	25822.	24
18	0	0	0	0	0	2	194	687	1436	2232	2863	3178	3332	3205	2691	1737	1230	888	321	40	0	0	0	0	24035.	24
19	0	0	0	0	0	2	228	852	1551	2094	2829	2489	2945	2970	2946	1697	894	429	598	92	0	0	0	0	22616.	24
20	0	0	0	0	0	3	141	474	941	1142	1565	2092	2937	2480	1893	2823	1932	1248	557	40%	0	0	0	0	20268.	24
21	0	0	0	0	0	2	141	706	1391	1830	2583	2907	2222	3340	3058	2480	1686	778	564	57%	0	0	0	0	23746.	24
22	0	0	0	0	0	1	127	688	1576	2345	3160	2128	2363	2836	1829	1473	867	804	198	9%	0	0	0	0	20404.	24
23	0	0	0	0	0	1	23	93	356	1210$	2064	2557	2597	2666	2929	985	1421	1404	470	42%	0	0	0	0	18818.	24
24	0	0	0	0	0	1	94	697	1034	873	1304	3068	2472	2825	2082	1269	639	819	364	35	0	0	0	0	17575.	24
25	0	0	0	0	0	9999*	9999*	9999*	1090*	1414	1892	2421	2312	2936	2370	2374	1614*	9999*	9999*	9999*	0	0	0	0	99999.*	16
26	0	0	0	0	0	1	195	772	1496	2181	2534	1326	2031	3170	2841	1174	1990	721	33	3	0	0	0	0	20467.	24
27	0	0	0	0	0	1	154	613	1433	2102	2766	3137	2831	2846	1864	1171	720	600	114	39%	0	0	0	0	20391.	24
28	0	0	0	0	0	1	41	390	305	1063$	1820	2634$	3448	2776	2876	2651	1886$	1120	428*	30*	0	0	0	0	21417.$	22
29	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
30	0	0	0	0	0	1	188	790	1515	2214	2741	3192	3378	3341	2785	1728	1869	1074	465	30%	0	0	0	0	25310.	24
31	0	0	0	0	0	1	150	742	1310	1955	2648	3170	3103	3187	2731	1956	1267	814	345	17%	0	0	0	0	23396.	24
AV	0	0	0	0	0	4$	208$	742$	1386$	1954$	2548$	2839$	2946$	3011$	2651$	2049$	1520$	964$	397$	44$	0	0	0	0	23264.$	
HR	31	31	31	31	31	27	26	26	26	29	29	29	29	29	29	29	28	27	26	26	31	31	31	31		694

FLAGS:
% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
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$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH)   YEAR 1980   MONTH 7

GLOBAL (RG630) KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	13	255	680	1098	1500	1838	1960	2098	2012	1824	1513	1197	750	441	69	0	0	0	0	17246.	24
2	0	0	0	0	0	2	186	566	960	1340	1631	1864	1896	1857	1716	1416	1035	672	291	33	0	0	0	0	15466.	24
3	0	0	0	0	0	3	91	296	784	1304	1472	1724	1914	1906	1737	1372	997	477	275	35	0	0	0	0	14386.	24
4	0	0	0	0	0	9	204	524	978	1142	1429	1540%	1876	1665%	1438%	1391	773%	602	214	33	0	0	0	0	13818.	24
5	0	0	0	0	0	3	249$	496	919	1280	1422%	1537	1863	1665	1715	1382	1101	687	284	29	0	0	0	0	14632.	24
6	0	0	0	0	0	6	130	538	954	1330	1639	1877	1790	1689	1101	147	10	8	9	5	0	0	0	0	11233.	24
7	0	0	0	0	0	19	246	645	1057	1429	1746	1966	1968	2010	1793	1521	1166	750	331	34	0	0	0	0	16682.	24
8	0	0	0	0	0	5	191	578	985	1368	1700	1908	2007	1957	1783	1514	1132	709	300	28	0	0	0	0	16164.	24
9	0	0	0	0	0	4	61*	238*	720*	704	1347	1815	1529	1193	1317%	1431	1054	679*	9999*	9999*	0	0	0	0	99999.*	18
10	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
11	0	0	0	0	0	9999*	9999*	9999*	1026*	1313	1645	1835	1837	1716	1543	1399	1019	555	209	32	0	0	0	0	99999.*	20
12	0	0	0	0	0	11	196	561	967	1361	1659	1851	1938	1808	1614	1266	778%	629	274	34	0	0	0	0	14947.	24
13	0	0	0	0	0	7	197	592	1006	1375	1685	1904	1974	1917	1746	1487	1096	723	307	33	0	0	0	0	16049.	24
14	0	0	0	0	0	4	116	467	898	1150	1495	1589	1228	1686	1393%	1034%	1001	607	266	28	0	0	0	0	12962.	24
15	0	0	0	0	0	5	128	446	893	1256	1448	983	1027	1436	1395	1152	972	670	236	21	0	0	0	0	12068.	24
16	0	0	0	0	0	5	156	504	899	1286	1589	1804	1907	1897	1758	1478	1022	669	278	57	0	0	0	0	15309.	24
17	0	0	0	0	0	2	118	499	809$	1119	1686	1917	1975	1956	1801	1534	1080	672	101	3	0	0	0	0	15272.	24
18	0	0	0	0	0	4	138	426	867	1319	1677	1855	1959	1882	1580	993%	704	539	183	25	0	0	0	0	14152.	24
19	0	0	0	0	0	4	155	531	924	1217	1641	1421	1702	1703	1704	953	499	238	373	65	0	0	0	0	13130.	24
20	0	0	0	0	0	5	91	282	540	642	870	1168	1656	1386	1065	1610	1097	721	330	23	0	0	0	0	11485.	24
21	0	0	0	0	0	3	96	425	817	1061	1490	1668	1263	1913	1743	1410	969	443	339	36	0	0	0	0	13676.	24
22	0	0	0	0	0	4	92	418	942	1377	1845	1207	1334	1598	1012	817	482	462	115	6	0	0	0	0	11712.	24
23	0	0	0	0	0	1	15	49	193	698$	1203	1479	1502	1547	1696	546	824	858	276	30	0	0	0	0	10916.	24
24	0	0	0	0	0	1	55	437	622	497	746	1822	1403	1655	1208%	717%	355	487	229	25	0	0	0	0	10257.	24
25	0	0	0	0	0	9999*	9999*	9999*	632*	805	1065	1381	1312	1669	1342	1361	921*	9999*	9999*	9999*	0	0	0	0	99999.*	16
26	0	0	0	0	0	1	135	498	914	1305	1495%	710%	1161%	1902	1657	651	1178	410	18	3	0	0	0	0	12038.	24
27	0	0	0	0	0	1	89	350	888	1264	1638	1830	1626	1636	1047	642	389	332	65	35	0	0	0	0	11832.	24
28	0	0	0	0	0	1	37	239	181	630$	1079	1543$	2007	1594	1663	1533	1099$	665	253*	20*	0	0	0	0	12516.$	22
29	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
30	0	0	0	0	0	1	128	509	942	1347	1659	1905	2015	1971	1645	1019%	1119	640	282	17	0	0	0	0	15199.	24
31	0	0	0	0	0	1	103	478	805	1191	1595	1897	1856	1925	1655	1182	757%	484	208	9	0	0	0	0	14146.	24
AV	0	0	0	0	0	5$	138$	463$	840$	1159$	1498$	1654$	1711$	1750$	1541$	1189$	889$	573$	240$	29$	0	0	0	0	13678.$	
HR	31	31	31	31	31	27	26	26	26	29	29	29	29	29	29	29	28	27	26	26	31	31	31	31		694

FLAGS:
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OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 7

DIFFUSE HORIZ. KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	16	132	214	289	345	411	599	498	525	560	523	437	491	397	125	0	0	0	0	5561.	24
2	0	0	0	0	0	9	191	354	511	695	866	970	1018	1005	920	936	807	555	316	88	0	0	0	0	9243.	24
3	0	0	0	0	0	15	188	533	949	1033	1601	1387	1092	1231	1154	1078	883	630	414	99	0	0	0	0	12286.	24
4	0	0	0	0	0	24	276	545	1085	1208	1247	1423	1470	1457	1396%	1195	921	679	346	104	0	0	0	0	13377.	24
5	0	0	0	0	0	18	293$	568	777	973	1229	1456	1452	1329	1143	1012	804	610	341	87	0	0	0	0	12090.	24
6	0	0	0	0	0	20	217	469	625	782	860	912	1239	1282	1284	349	59	46	47	18	0	0	0	0	8209.	24
7	0	0	0	0	0	26	185	240	297	442	526	592	722	681	611	565	455	339	231%	74	0	0	0	0	5985.	24
8	0	0	0	0	0	15	189	357	513	652	727	764	879	833	778	736	687	541	315%	86	0	0	0	0	8071.	24
9	0	0	0	0	0	17	148*	432*	1026*	1096	1575	1328	1432	1516	1436	1319	1085	858*	9999*	9999*	0	0	0	0	99999.*	18
10	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
11	0	0	0	0	0	9999*	9999*	9999*	709*	795	872	993	1170	1338	1480	1394	944	597	336	88	0	0	0	0	99999.*	20
12	0	0	0	0	0	19	187	396	571	664	871	1020	1043	1041	1048	1069	889	697	394	95	0	0	0	0	10004.	24
13	0	0	0	0	0	14	165	308	397	498	588	619	650	697	706	754	739	622	335	78	0	0	0	0	7173.	24
14	0	0	0	0	0	13	216	558	862	1274	1608	1720	1666	1705	1537%	1233%	1041	708	375	85	0	0	0	0	14601.	24
15	0	0	0	0	0	13	215	569	838	1074	1411	1478	1446	1542	1431%	1248%	1010	791	350	72	0	0	0	0	13489.	24
16	0	0	0	0	0	11	200	484	740	952	1189	1337	1287	1268	1255	1093	1094	778	442	65	0	0	0	0	12194.	24
17	0	0	0	0	0	6	168	398	772$	1145	1082	760	727	617	610	605	606	517	200	22	0	0	0	0	8235.	24
18	0	0	0	0	0	10	182	373	628	1057	818	934	989	987	1074	1060	748	607	306	85	0	0	0	0	9857.	24
19	0	0	0	0	0	12	215	470	703	855	1093	1310	1447	1374	1243	1089	767	426	400	109	0	0	0	0	11513.	24
20	0	0	0	0	0	11	148	478	891	975	1079	1182	1159	1151	1028	601	454	411	212	62	0	0	0	0	9841.	24
21	0	0	0	0	0	8	115	362	504	622	592	625	784	675	735	624	611	440	273	39	0	0	0	0	7010.	24
22	0	0	0	0	0	7	107	287	434	536	1053	1621	1663	1580	1311	1310	786	684	167	14	0	0	0	0	11562.	24
23	0	0	0	0	0	1	52	128	384	917$	1450	1661	1663	1231	942	961	1109	808	376	78	0	0	0	0	11761.	24
24	0	0	0	0	0	3	130	486	818	904	1299	1980	1694	1498	1241	1070%	674	742	339	62	0	0	0	0	12937.	24
25	0	0	0	0	0	9999*	9999*	9999*	963*	1053	1254	1302	1284	1012	1075	822	702*	9999*	9999*	9999*	0	0	0	0	99999.*	16
26	0	0	0	0	0	4	186%	407%	516	634	983	1065%	1195%	1171	1179	845	1029	571	73	14	0	0	0	0	9871.	24
27	0	0	0	0	0	4	180	528	855	1202	1296	1309	1491	1366	1226%	1126	767	632	163	37	0	0	0	0	12181.	24
28	0	0	0	0	0	1	72	417	341	832$	1323	1324$	1325	1594	1591	1039	811$	584	367*	63*	0	0	0	0	11661.$	22
29	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
30	0	0	0	0	0	2	149	382	557	672	740	813	848	858	863	858	751	593	308	53	0	0	0	0	8449.	24
31	0	0	0	0	0	2	167	443	655	879	954	1238	1401	1515	1533	1205	902	617	308	47	0	0	0	0	11866.	24
AV	0	0	0	0	0	11$	174$	414$	635$	854$	1055$	1163$	1198$	1175$	1117$	956$	781$	582$	299$	69$	0	0	0	0	10482.$	
HR	31	31	31	31	31	27	26	26	26	29	29	29	29	29	29	29	28	27	26	26	31	31	31	31		694

FLAGS:

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OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 7

LAT. TILTED KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
												HOUR														
1	0	0	0	0	0	12	119	601	1364	2108	2760	3041	3290	3153	2803	2218	1638	883	391	79	0	0	0	0	24460.	24
2	0	0	0	0	0	8	140	558	1225	1914	2476	2936	3021	2947	2661	2094	1424	787	262	41	0	0	0	0	22494.	24
3	0	0	0	0	0	9	139	432	1129	1874	2140	2750	3049	2994	2673	2034	1359	601	312	50	0	0	0	0	21546.	24
4	0	0	0	0	0	11	193	578	1323	1702	2178	2445	3006	2675	2268	2109	1172	767	243	45	0	0	0	0	20715.	24
5	0	0	0	0	0	9	289$	570	1205	1856	2205	2454	2986	2717	2722	2103	1562	841	278	38	0	0	0	0	21836.	24
6	0	0	0	0	0	11	145	569	1242	1939	2546	3003	2913	2731	1753	248	17	17	16	15	0	0	0	0	17164.	24
7	0	0	0	0	0	14	162	629	1317	2024	2632	3063	3102	3179	2787	2264	1611	852	247	34	0	0	0	0	23918.	24
8	0	0	0	0	0	8	133	565	1250	1945	2584	3005	3196	3124	2780	2253	1576	849	272	36	0	0	0	0	23578.	24
9	0	0	0	0	0	9	91*	339*	990*	1029	2094	2879	2436	1881	2029	2138	1524	952*	9999*	9999*	0	0	0	0	99999.*	18
10	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
11	0	0	0	0	0	9999*	9999*	9999*	1376*	1911	2557	2931	2977	2780	2388	2055	1430	711	256	48	0	0	0	0	99999.*	20
12	0	0	0	0	0	8	128	551	1234	1953	2544	2934	3135	2914	2554	1927	1149	774	289	45	0	0	0	0	22138.	24
13	0	0	0	0	0	7	111	557	1273	1969	2587	3033	3214	3127	2796	2261	1545	858	288	34	0	0	0	0	23659.	24
14	0	0	0	0	0	6	135	546	1186	1712	2322	2538	1981	2692	2145	1640	1366	766	289	37	0	0	0	0	19361.	24
15	0	0	0	0	0	6	141	519	1149	1776	2183	1588	1595	2259	2123	1672	1277	828	271	31	0	0	0	0	17419.	24
16	0	0	0	0	0	6	130	532	1154	1854	2447	2879	3097	3071	2780	2240	1480	881	364	64	0	0	0	0	22980.	24
17	0	0	0	0	0	6	111	537	1098$	1659	2612	3087	3214	3175	2860	2347	1525	823	149	14	0	0	0	0	23217.	24
18	0	0	0	0	0	6	116	496	1184	2060	2647	2981	3164	3020	2470	1547	1040	671	205	35	0	0	0	0	21641.	24
19	0	0	0	0	0	6	152	576	1242	1851	2606	2346	2785	2761	2737	1546	824	406	364	62	0	0	0	0	20263.	24
20	0	0	0	0	0	5	93	392	801	970	1421	1888	2789	2355	1743	2493	1606	877	240	26	0	0	0	0	17699.	24
21	0	0	0	0	0	5	117	509	1099	1606	2339	2727	2085	3176	2830	2225	1433	613	333	40	0	0	0	0	21136.	24
22	0	0	0	0	0	5	98	482	1234	2032	2891	1968	2170	2621	1712	1322	702	651	165	19	0	0	0	0	18072.	24
23	0	0	0	0	0	5	28	95	335	1110$	1885	2389	2501	2541	2727	880	1193	1107	342	42	0	0	0	0	17181.	24
24	0	0	0	0	0	5	81	505	861	714	1111	2874	2372	2673	1939	1167	528	690	258	31	0	0	0	0	15811.	24
25	0	0	0	0	0	9999*	9999*	9999*	881*	1246	1735	2287	2224	2771	2196	2131	1396*	9999*	9999*	9999*	0	0	0	0	99999.*	16
26	0	0	0	0	0	4	110	521	1220	1950	2375	1277	1896	3024	2656	1101	1663	575	45	12	0	0	0	0	18431.	24
27	0	0	0	0	0	4	125	440	1203	1859	2588	3002	2714	2693	1731	1077	619	489	112	34	0	0	0	0	18690.	24
28	0	0	0	0	0	4	44	333	276	993$	1711	2497$	3284	2646	2647	2439	1655$	871	295*	28*	0	0	0	0	19675.$	22
29	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
30	0	0	0	0	0	4	107	543	1259	2008	2604	3104	3319	3271	2684	1628	1623	827	289	23	0	0	0	0	23294.	24
31	0	0	0	0	0	3	98	517	1095	1785	2535	3077	3055	3102	2615	1821	1131	654	242	20	0	0	0	0	21752.	24
AV	0	0	0	0	0	7$	125$	506$	1114$	1704$	2321$	2655$	2778$	2830$	2442$	1827$	1274$	728$	251$	37$	0	0	0	0	20598.$	
HR	31	31	31	31	31	27	26	26	26	29	29	29	29	29	29	29	28	27	26	26	31	31	31	31		694

FLAGS:

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OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 7

INFRARED 10 KJ/M2

DAY	HOUR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	----	--
1	123	121	121	121	121	125	137	140	138	132	124	120	116	122	129	136	142	148	153	147	140	139	139	137	3174.	24
2	137	135	135	135	134	136	145	150	152	147	140	135	135	138	142	149	155	158	159	154	149	148	148	147	3463.	24
3	145	147	150	146	147	147	152	154	153	149	147	139	1456	138	142	149	154	158	160	156	151	151	150	151	4894.	24
4	153	150	149	153	152	148	157	159	160	156	153	152	1523	1542	153	156	162	162	163	160	155	154	153	152	6475.	24
5	151	149	149	149	149	150	154$	158	158	155	154	1541	146	146	147	155	158	162	164	160	153	152	153	151	5063.	24
6	149	148	148	146	146	150	155	159	158	154	148	141	154	1543	162	1629	1618	154	152	150	146	144	141	140	7935.	24
7	139	136	135	132	130	131	132	139	144	140	133	128	128	130	136	141	146	152	154	148	141	140	140	140	3316.	24
8	140	138	137	137	136	137	146	151	150	146	139	133	132	135	139	145	152	158	160	154	148	149	150	150	3458.	24
9	150	149	148	150	152	156	155*	158*	160*	159	153	145	1567	162	160	158	163	167*	0*	0*	0*	0*	0*	0*	99999.*	14
10	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	99999.*	0
11	0*	0*	0*	0*	0*	0*	0*	0*	158*	154	147	143	146	150	157	161	165	169	174	167	161	158	157	155	99999.*	15
12	153	150	148	148	147	148	156	160	159	154	149	144	143	1530	153	162	169	171	173	167	160	163	157	158	5122.	24
13	153	149	146	145	144	145	154	157	156	152	146	140	141	1521	149	158	166	171	170	160	154	154	153	151	5036.	24
14	149	149	148	147	147	148	153	157	159	156	152	152	157	1532	156	159	161	163	163	159	154	153	153	153	5082.	24
15	151	151	149	147	146	148	154	156	158	154	152	160	163	154	159	163	165	167	162	159	155	154	1537	1513	6477.	24
16	150	150	148	146	145	146	153	158	159	157	152	148	148	150	155	159	167	168	168	165	159	158	155	152	3717.	24
17	149	148	147	147	146	145	151	155	155$	155	150	143	144	145	148	155	162	169	171	161	153	150	149	149	3646.	24
18	146	143	136	138	140	137	145	150	152	146	140	136	136	140	147	158	162	166	163	157	150	149	148	150	3537.	24
19	149	146	145	144	142	143	149	154	153	149	143	1494	1499	142	144	156	199*	171*	155	152	149	150	149	147	6514.$	22
20	145	142	140	139	138	138	148	159	157	157	1510	1521	1482	1506	1546	144	152	157	159	153	156	1534	149	145	11777.	24
21	143	143	140	141	141	142	157	158	155	149	1440	143	1516	1442	1436	148	156	157	158	152	147	146	144	146	8801.	24
22	145	146	144	141	139	143	149	149	151	146	1420	1518	1529	1469	1506	155	159	159	160	155	153	156	153	148	10292.	24
23	150	149	147	147	147	149	151	152	151	145$	139	1452	1498	1495	139	161	157	156	152	149	153	155	146	143	7582.	24
24	150	151	144	141	143	150	149	150	155	157	157	141	142	1487	150	157	157	156	154	147	143*	0*	0*	0*	4988.$	20
25	0*	0*	0*	0*	0*	0*	0*	0*	154*	151	149	139	1508	1462	1496	148	153*	0*	0*	0*	0*	0*	145*	144	99999.*	8
26	143	142	142	141	140	141	148	153	153	148	150	149	149	139	142	159	153	157	158	152	151	149	148	147	3556.	24
27	148	149	148	146	149	142	148	149	152	147	142	136	1473	1495	154	161	1565	156	158	152	144	142	141	140	7638.	24
28	138	138	136	135	142	150	156	156	158	153$	148	793$	1439	1468	142	1445	798$	151	152*	148*	143*	141*	0*	0*	9630.$	18
29	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	136*	134	99999.*	1
30	134	132	131	129	128	129	137	144	145	143	139	132	131	132	136	150	151	156	156	148	144	143	142	141	3355.	24
31	138	136	136	137	136	138	148	152	153	153	149	144	1472	146	153	1528	1552	161	160	153	149	148	147	147	7636.	24
--	---	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	-----	
AV	145$	144$	142$	142$	142$	143$	149$	153$	154$	150$	282$	399$	703$	750$	334$	297$	340$	160$	161$	155$	151$	206$	204$	198$	5802.$	
HR	27	27	27	27	27	27	26	26	26	29	29	29	29	29	29	29	27	26	26	26	25	25	25	27		650

FLAGS:

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OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1980 MONTH 7

ULTRAVIOLET KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	2	18	48	84	119	151	164	174	165	144	116	87	55	28	7	0	0	0	0	1361.	24
2	0	0	0	0	0	1	16	41	71	103	129	151	154	150	136	106	76	49	24	6	0	0	0	0	1214.	24
3	0	0	0	0	0	1	11	29	65	102	123	144	155	146	131	103	74	41	22	6	0	0	0	0	1153.	24
4	0	0	0	0	0	1	16	42	75	96	121	131	152	141	120	107	72	48	22	5	0	0	0	0	1149.	24
5	0	0	0	0	0	1	20$	39	72	102	120	132	154	142	139	111	84	51	24	6	0	0	0	0	1199.	24
6	0	0	0	0	0	1	16	42	75	108	137	159	152	143	93	25	4	3	4	2	0	0	0	0	964.	24
7	0	0	0	0	0	1	18	48	81	111	139	159	157	160	138	116	86	54	26	6	0	0	0	0	1301.	24
8	0	0	0	0	0	1	16	42	73	106	136	154	160	154	138	113	81	50	25	6	0	0	0	0	1254.	24
9	0	0	0	0	0	1	11*	26*	58*	67	111	141	123	96	96	97	71	50*	9999*	9999*	0	0	0	0	99999.*	18
10	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
11	0	0	0	0	0	9999*	9999*	9999*	78*	103	134	149	151	140	119	97	73	39	17	5	0	0	0	0	99999.*	20
12	0	0	0	0	0	1	15	40	72	105	131	148	159	148	127	95	65	43	20	5	0	0	0	0	1173.	24
13	0	0	0	0	0	1	15	43	76	108	134	158	166	160	142	115	80	48	22	6	0	0	0	0	1274.	24
14	0	0	0	0	0	1	13	38	70	98	123	134	114	138	113	93	72	47	23	5	0	0	0	0	1082.	24
15	0	0	0	0	0	1	12	36	66	91	109	93	88	110	103	81	63	44	21	5	0	0	0	0	924.	24
16	0	0	0	0	0	1	13	38	64	98	124	142	153	150	133	110	73	46	23	5	0	0	0	0	1172.	24
17	0	0	0	0	0	1	12	38	65$	92	131	156	161	159	141	117	78	45	12	2	0	0	0	0	1210.	24
18	0	0	0	0	0	1	13	38	70	110	139	156	159	149	124	89	64	40	21	5	0	0	0	0	1179.	24
19	0	0	0	0	0	1	14	42	77	109	143	134	151	152	142	92	50	30	24	5	0	0	0	0	1166.	24
20	0	0	0	0	0	1	13	29	57	72	101	124	163	141	107	137	93	58	27	6	0	0	0	0	1130.	24
21	0	0	0	0	0	1	10	37	73	100	137	156	129	171	153	122	81	44	26	6	0	0	0	0	1247.	24
22	0	0	0	0	0	0	10	38	77	116	155	120	131	153	108	86	54	44	15	3	0	0	0	0	1109.	24
23	0	0	0	0	0	0	4	9	26	69$	113	135	139	135	144	60	72	55	24	5	0	0	0	0	989.	24
24	0	0	0	0	0	0	10	37	54	54	75	144	133	137	105	72	41	41	19	4	0	0	0	0	926.	24
25	0	0	0	0	0	9999*	9999*	9999*	64*	85	112	136	128	155	125	117	81*	9999*	9999*	9999*	0	0	0	0	99999.*	16
26	0	0	0	0	0	0	12	37	70	103	122	89	110	156	133	68	84	40	5	1	0	0	0	0	1030.	24
27	0	0	0	0	0	0	12	35	72	104	135	157	147	144	103	69	48	38	11	2	0	0	0	0	1077.	24
28	0	0	0	0	0	0	5	25	22	60$	99	137$	174	146	140	127	89$	51	23*	4*	0	0	0	0	1100.$	22
29	0	0	0	0	0	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	9999*	0	0	0	0	99999.*	9
30	0	0	0	0	0	0	12	38	71	104	127	150	159	157	128	83	77	47	22	4	0	0	0	0	1178.	24
31	0	0	0	0	0	0	10	35	62	90	121	140	137	133	111	82	57	39	18	3	0	0	0	0	1039.	24
AV	0	0	0	0	0	1$	13$	37$	67$	96$	125$	141$	146$	146$	125$	97$	70$	44$	20$	5$	0	0	0	0	1133.$	
HR	31	31	31	31	31	27	26	26	26	29	29	29	29	29	29	29	28	27	26	26	31	31	31	31		694

FLAGS:

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OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH)   YEAR 1980   MONTH 7

AVAILABLE SUNSHINE %

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVG	HR
1	0	0	0	0	0	6	100	100	100	100	100	100	100	100	100	94%	100%	100	100	29	0	0	0	0	93.	24
2	0	0	0	0	0	0	51	87%	100%	99	100	100	100	100	100	100	100	100	79	0	0	0	0	0	85.	24
3	0	0	0	0	0	0	0	0	35	88	64	80	98	100	100	98	99	24	0	0	0	0	0	0	56.	24
4	0	0	0	0	0	0	9	85	69	80	84	71	92	74	74	92	55	71	0	0	0	0	0	0	61.	24
5	0	0	0	0	0	0	0	49	100	98	75	67	87	78	94	84	98	100	72	0	0	0	0	0	72.	24
6	0	0	0	0	0	0	0	87	100	100	100	100	86	80	44	0	0	0	0	0	0	0	0	0	49.	24
7	0	0	0	0	0	0	80	100	100	99	100	100	99	100	100	100	100	100	100	33	0	0	0	0	92.	24
8	0	0	0	0	0	0	55	100	100	100	100	100	100	100	100	100	100	100	98	0	0	0	0	0	89.	24
9	0	0	0	0	0	0	0	0	10	0	51	100	67	40	69	97	84	10	0	0	0	0	0	0	46.	24
10	0	0	0	0	0	0	10	70	100	100	100	100	100	80	20	40	50	0	0	0	0	0	0	0	0.	24
11	0	0	0	0	0	0	0	40	100	99	100	100	95	89	82	90	88	61	7	0	0	0	0	0	76.	24
12	0	0	0	0	0	0	55	100	100	100	100	100	99	95	92	84	64	88	0	0	0	0	0	0	76.	24
13	0	0	0	0	0	0	69	100	100	100	100	100	100	100	100	100	97	100	94	3	0	0	0	0	90.	24
14	0	0	0	0	0	0	0	44	93	65	70	65	33	75	64	55	88	87	15	0	0	0	0	0	54.	24
15	0	0	0	0	0	0	0	16	100	100	78	22	23	61	68	69	91	93	0	0	0	0	0	0	51.	24
16	0	0	0	0	0	0	0	88	100	100	100	100	100	98	99	100	77	88	0	0	0	0	0	0	75.	24
17	0	0	0	0	0	0	0	4%	90	72	100	100	100	100	100	100	97	94	6	0	0	0	0	0	68.	24
18	0	0	0	0	0	0	16	58	75	71	100	100	100	100	94	56	54	63	3	0	0	0	0	0	54.	24
19	0	0	0	0	0	0	4	100	95	90	95	56	72	80	90	46	17	4	65	0	0	0	0	0	58.	24
20	0	0	0	0	0	0	7	2	7	15	23	37	69	56	40	100	92	93	100	10	0	0	0	0	46.	24
21	0	0	0	0	0	0	0	32	66	57	77	76	45	88	96	90	74	46	69	16	0	0	0	0	59.	24
22	0	0	0	0	0	0	3	52	94	98	89	22	29	57	19	2	0	1	0	0	0	0	0	0	34.	24
23	0	0	0	0	0	0	0	0	0	0	31	45	43	61	82	5	30	100	50	0	0	0	0	0	33.	24
24	0	0	0	0	0	0	0	60	40	0	1	65	41	72	57	16	0	0	0	0	0	0	0	0	25.	24
25	0	0	0	0	0	0	0	0	20	26	36	49	42	75	59	81	70	40	10	0	0	0	0	0	52.	24
26	0	0	0	0	0	0	20	100	100	100	80	15	42	91	89	26	100	29	0	0	0	0	0	0	57.	24
27	0	0	0	0	0	0	0	27	79	91	100	94	66	67	33	2	0	0	0	0	0	0	0	0	40.	24
28	0	0	0	0	0	0	0	0	0	0	33	80	89	69	68	92	60	91	10	0	0	0	0	0	43.	24
29	0	0	0	0	0	0	10	70	100	100	100	100	100	100	100	100	80	40	0	0	0	0	0	0	0.	24
30	0	0	0	0	0	0	26	100	100	100	100	100	100	100	90	68	100	95	88	0	0	0	0	0	85.	24
31	0	0	0	0	0	0	0	79	86	89	100	100	93	100	92	75	69	68	8	0	0	0	0	0	70.	24
AV	0	0	0	0	0	0	19	59	76	75	79	77	76	83	79	69	69	65	36	4	0	0	0	0	62.	
HR	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31		744

FLAGS:

% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS

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E16-C03

ORO/5604-81-2

PROGRAM FOR SOLAR ENERGY METEOROLOGICAL RESEARCH AND TRAINING SITE (REGION 3)

Quarterly Technical Status and
Contract Management Report

C. G. Justus, Principal Investigator

Georgia Institute of Technology
Atlanta, GA 30332

April 1981

Report Period January 1, 1981 - March 31, 1981

PREPARED FOR THE UNITED STATES
DEPARTMENT OF ENERGY

DIVISION OF DISTRIBUTED SOLAR TECHNOLOGY

UNDER GRANT DEFG05-77-ET20153

Georgia Tech Project E-16-C03

1. PROJECT OBJECTIVES

This broad program of solar energy and meteorological monitoring, training, and research has the following main objectives for the proposed 5 years duration:

(1) to provide for the Southeast Region (Region 3) a set of continuously monitored and quality controlled data on solar radiation and atmospheric phenomena related to solar energy collection, conversion, and storage, and to relate these to the extensive ongoing solar energy research and engineering projects carried out by Georgia Tech and in the Southeast Region.

(2) by analysis of monitoring results at two sites (on campus, adjacent to the Georgia Tech thermal Test facility and off-campus adjacent to the Shenandoah Solar Total Energy Site), determine: a) optimum siting of solar radiation and meteorological monitoring instruments relative to solar energy systems to provide the most representative site data with the least influence from the solar collector systems, b) adequacy and representativeness for the Southeast Region of various methodologies for relating easily measured phenomena (minutes of sunshine, cloud cover, etc.) to engineering quality solar radiation data (direct, diffuse, and global insolation, etc.).

(3) to establish and maintain a training program which will allow: a) undergraduate and graduate engineering students, through elective or minor courses, to become informed in the areas of meteorology and atmospheric science as they relate to solar and wind energy, b) graduate students in the atmospheric sciences to become informed of the specific requirements of monitoring, analysis, interpretation and presentation of meteorological information related to engineering aspects of solar and wind

energy, c) professionals in various fields, through short courses and seminars, to become familiar with the new and rapidly developing aspects of solar energy engineering and technology, especially the radiation monitoring and meteorological aspects of this field.

(4) through cooperation in the 3/2 dual degree program, the National Consortium for Graduate Degrees for Minorities in Engineering and other academic programs, enhance the opportunities for minorities (especially Black American and Puerto Ricans) and women in the solar energy engineering and technology field.

(5) instrumentation and monitoring techniques research and development to enhance the engineering applicability of the solar radiation and meteorological monitoring and to provide better instructional tools through low cost instrument systems for educational purposes.

(6) to investigate, with the fixed site instruments and the portable monitoring units (PMU's), the influence of urban haze and aerosols as well as the high levels of natural turbidity which occur in parts of the Southeast region, and with the PMU's to sample the effects on solar radiation of a wide variety of geography (which spans coastal, piedmont plains, and mountainous within the Southeast region).

2. PROJECT PLAN

A. Research Approach and Definition of Tasks

The proposed project plan is divided into three major tasks, each with several subtasks, as follows:

Task 1: Solar Radiation and Meteorological Monitoring Program

This task includes acquisition, initial calibration, and installation of the solar radiation and meteorological instrumentation at the on-campus (Solar Thermal Test Facility/Wind Turbine Test Facility) site and the off-campus (Shenandoah Georgia Solar Total Energy Project) site. Existing and new instrumentation at these sites will be combined and interfaced through data loggers and magnetic tape recording into a form which can be processed, summarized, and formatted by the main campus computer (CYBER 70/74 system). Annual calibration of the instrumentation, against national standards where appropriate, will be carried out, as well as more frequent field calibration of the radiation monitoring instruments. A carefully monitored program of daily instrument inspection and routine maintenance will also be carried out. The detailed outline of the various subtasks under Task 1 is as follows:

a. Based on the proposed variables to be monitored, the Instrumentation Network Design will be laid out using equipment assigned by Georgia Tech for use on this program and additional units to be purchased with the sponsor's approval.

b. Using the preliminary network design, the Selection, Order, and Delivery will be based on recommendations made at the preliminary review meeting of all of the principal investigators.

c. Before an instrument or support unit is put into service, each piece of equipment will be examined and subjected to an Instrument Check and Certification for conformation to Georgia Tech and vendor specifications.

Instruments which fail to pass inspection will be returned to the vendor for replacement.

d. The design, fabrication, and installation of the Auxiliary Hardware which will house and/or support the instrumentation will be according to recommendations in the above articles, of the respective vendors, and to experience gained through use of similar apparatus.

e. Campus Site Modification and Preparation will be done as necessary to accomodate the new monitoring site and instrumentation.

f. The Relocation of Existing Instruments will be performed expeditiously to prevent a loss of data in the present continuous monitoring system. Exposure and operation of the solar radiation and meteorological monitoring instruments will be in accordance with criteria and guidelines published by the WMO(1971) and the IGY (1958).

g. The Instrumentation will be installed and calibrated after it is received and certified.

h. Campus Site Monitoring for the total system is scheduled to begin during the last month of Year 1, but a continuous monitoring system will have been in use for the entire period.

i. The Shenandoah Monitoring System will be used for the entire period after the "Sandia Solar Monitor System" is installed. This basic instrument package will be augmented by additional equipment. Data from the Shenandoah System will be logged on cassette tape. It will then be reformatted and merged with the campus site monitoring data on the CYBER system and put on magnetic tape.

j. Analytical Software will be developed in a standard format which will be used for all research sites. This format was selected at the project directors meeting in Washington, D. C. Data will be taken for analysis

to the CYBER 70/74 computer for transfer to the standard format and storage in this format on magnetic tape, and for transmittal of the raw and summarized data to the National Climatic Center in Asheville.

k. An Instrumentation Calibration by use of a set of special instruments or by techniques specified by the instrument vendor will be performed quarterly to verify instrument accuracy and to establish a permanent record of possible instrument degradation which would affect the acquired data.

l. At the end of each phase of the program, the set of standards would be taken to the Solar Radiation Calibration Facility in Denver, Colorado for Certification of Standard Instruments.

m. The Data Transfer to the National Climatic Center is scheduled to begin on a monthly basis at the end of Year 1 and would continue for the next 48 months. The data will also be stored at Georgia Tech.

Task 2: Solar Energy/Meteorology Training Program

This task involves development and implementation of on-campus, immediate area, and regional training. Existing graduate courses in general meteorology and boundary layer meteorology will be expanded by a new graduate course (open to seniors) in the area of meteorology for solar and wind energy. This course will include training in instrumentation, data acquisition, reduction and analysis. With the formation of an Atmospheric Sciences academic program anticipated to begin in September 1978, this academic curriculum will offer engineers and engineering technologists the opportunity to learn, as a minor or elective course basis, fundamentals of meteorology as it applies to solar energy engineering and technology. It will also allow meteorologists and atmospheric science students in the new program to interact with and learn about the engi-

neering problems and needs related to solar energy technology. This academic program and related short courses for professionals will be made available as appropriate through a unique instructional TV system to become operational at Georgia Tech in September 1978. A "traveling course" to be put on as a short course or a one quarter course at regional colleges will also be implemented. Initially this will be conducted by Georgia Tech personnel. Later, as arrangements are worked out and the local college has personnel trained to proctor or tutor the course, this will be carried via the TV system, either on a video cassette delivery basis, or if the system is developed, via a satellite TV link.

Task 3: Instrumentation and Monitoring Techniques Research

Various research and development aspects related both to the monitoring and the training program, will be carried out under this task. The location of the two monitoring sites - one on-campus within about two miles from the heart of downtown Atlanta, one at the new town Shenandoah site, about 45 miles from Atlanta - will allow evaluation of urban/rural differences, especially related to urban haze and aerosols. The exposure of the instruments adjacent to the Solar Thermal Test Facility and Wind Turbine Test Facility at Georgia Tech will allow evaluation of potential effects on temperature, moisture, and air flow near such facilities. Hence optimum locations will be evaluated for instruments near solar energy facilities, to provide maximum degree of representativeness and minimum influence from the solar energy system on the meteorological measurements. Many models have been proposed in which various meteorological and simply measured radiation parameters (sunshine hours, temperature, cloud cover, solar declination, etc.) can be used to estimate engineering quality insolation (global and direct insolation, global on inclined surfaces, etc.). Some of these methods are those of Fritz (1957), Angstrom (1956), Black et al (1954), Glover and McCulloch (1958), Sabbagh et al (1977), Liu and Jordan (1960),

Whillier (1956) Bennett (1965), Swartman and Ogunladeo (1967), Reddy (1971a, 1971b), Norris (1966), Masson (1966), Atwater (1974), Lumb (1964), L'Vova (1972), Machta (1974), Paltridge (1974), Lin (1973), and Randall et al (1977). Through NOAA (Machta, private communication) a set of linear regression coefficients is being developed for the 26 rehabilitated solar radiation data stations. Using this model, the National Climatic Center will prepare, by November 1977, solar radiation estimates for 200 stations in the U.S. These data will be put on magnetic tape in SOLMET format. The data from the on-campus and off-campus monitoring sites as well as from the 5 Southeastern sites in the new 35 site NOAA network (Riches, 1975) will be used to study regional relationships between simply monitored parameters and solar radiation data for engineering purposes. Results of the contract study resulting from the recent RFP to Perform a Solar Radiation Data Forecast and Interpolation Analysis will also be applied in this study. Emphasis will be on study of the influence of turbidity (high in parts of the Southeast region), and regional geography (which spans coastal, piedmont plains, and mountain areas). During the second and subsequent years up to three low cost portable monitoring units will be designed and built. These units will be used in the training program as instructional systems for the traveling course to regional colleges. Data from these units will also be used in the analysis of methods to relate simple measured parameters to engineering quality insolation data for the region. Other instrument and monitoring techniques for which research and development projects are envisioned will include:

a. an automatic filter changing wheel for the normal incidence pyrheliometer (to automatically switch on a 1/minute or less basis between clear, OG1, RG2, and RG8 filters),
b. circumsolar radiation with the Lawrence Berkley Labs circumsolar telescope, currently on campus and projected to remain here throughout at least a portion of this project, and

c. an automatic wide field of view camera system to provide a film record of cloud cover conditions.

3. ADMINISTRATIVE STATUS

No administrative changes have been made. The project team and organization is now as shown in Figure 3.1.

4. PROGRESS TO DATE

Task 1: Solar Radiation and Meteorological Monitoring Program

a. Completed in prior period. No modifications required.

b. Completed in prior period. No modifications required.

c. Completed in prior period.

d. Completed in prior period.

e. Completed in prior period. Campus site now in full operation.

f. Completed in prior period.

g. During an earlier quarter, the traveling standard CSIRO total radiometer was received and compared to Georgia Tech and Shenandoah total radiometers. Some results were reported at the Davis review meeting. Word on whether large differences (∿10%) in short-wave and long-wave calibrations are real is still being awaited from Trinity University.

h. Campus-site monitoring continues. Except for the usual maintenance, all instrumentation functioned properly throughout the quarter.

i. The Shenandoah monitoring system continues in operation. Data reduction and quality control is current.

j. Completed in prior period. Routine daily spot checks continue for the serial output from the on-campus site.

k. See item g, above.

l. A PSP calibration was done at NOAA in September 1980. Further comparisons and sun-shade checks against the Kendall active cavity radiometer will be done in the next calibration tests.

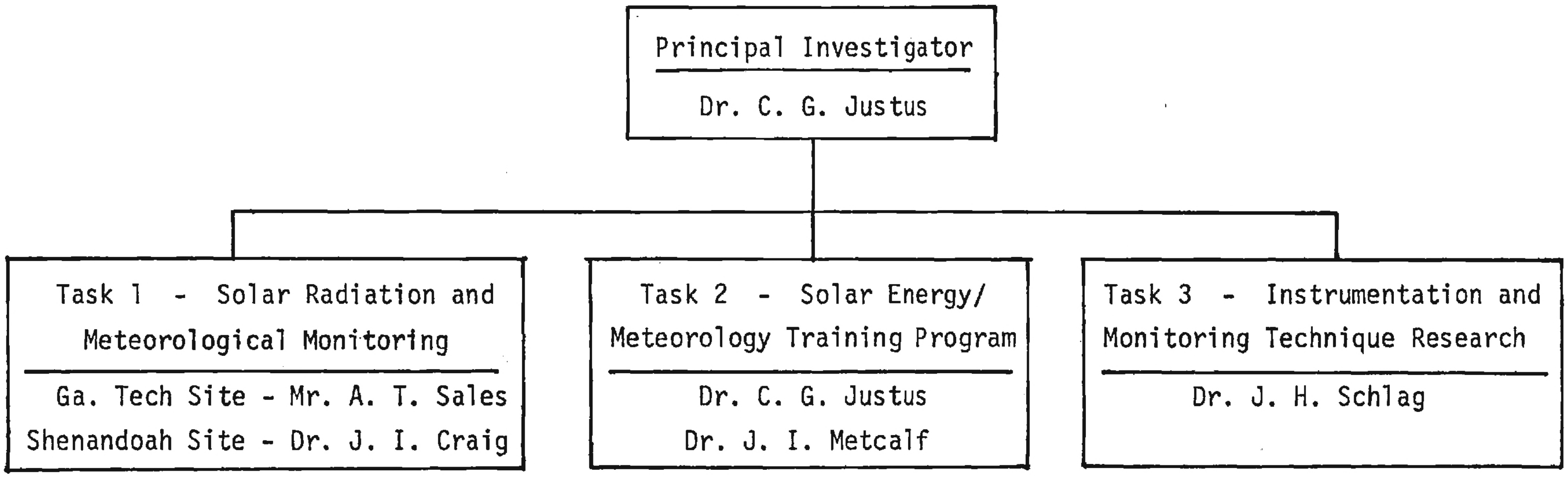


Figure 3.1 - Project Organization Chart

m. Transfer of one year of on-campus data and Shenendoah data to NCC is complete. Further data will be transferred as it is processed.

Task 2: Solar Energy/Meteorological Training Program

The NSF minority graduate training program "Graduate Research Opportunities in Atmospheric and Terrestrial Sciences" has been funded. A site visit by our Mobile Atmospheric Research Vehicle (MARV) and newly acquired tethered balloon system was conducted at Jackson State University, a minority college in Jackson, Mississippi, March 23-27, 1981. A program from that visit is attached. Operations of the tethered balloon at Jackson State are also described in an appendix in this report.

Task 3: Instrumentation and Monitoring Techniques Research

Because od continuing problems with the MARS data logger, the portable trailer system is being discontinued. Instead a combination of instruments have been mounted in the MARV unit. Mounting of these instruments in the MARV van is complete.

The all-sky camera system continues to operate well. A visiting faculty member from Jamaica, assisted by a student are continuing quantitative analyses of these data.

The photocell direct beam radiometer continues to undergo field tests. It still appears to compare quite closely with NIP readings (generally $\leq$ 5% error). The automated sun photometer is in operation, ater the μA current amplifier to yield suitable voltage level output signals have been constructed.

Operation of the Lawrence Berkely labs circumsolar telescope on the Georgia Tech campus has now shifted from the personnel of the Advanced Components Test Facility to personnel directly working on this project. Some instrumentation problems with this unit persist, however.

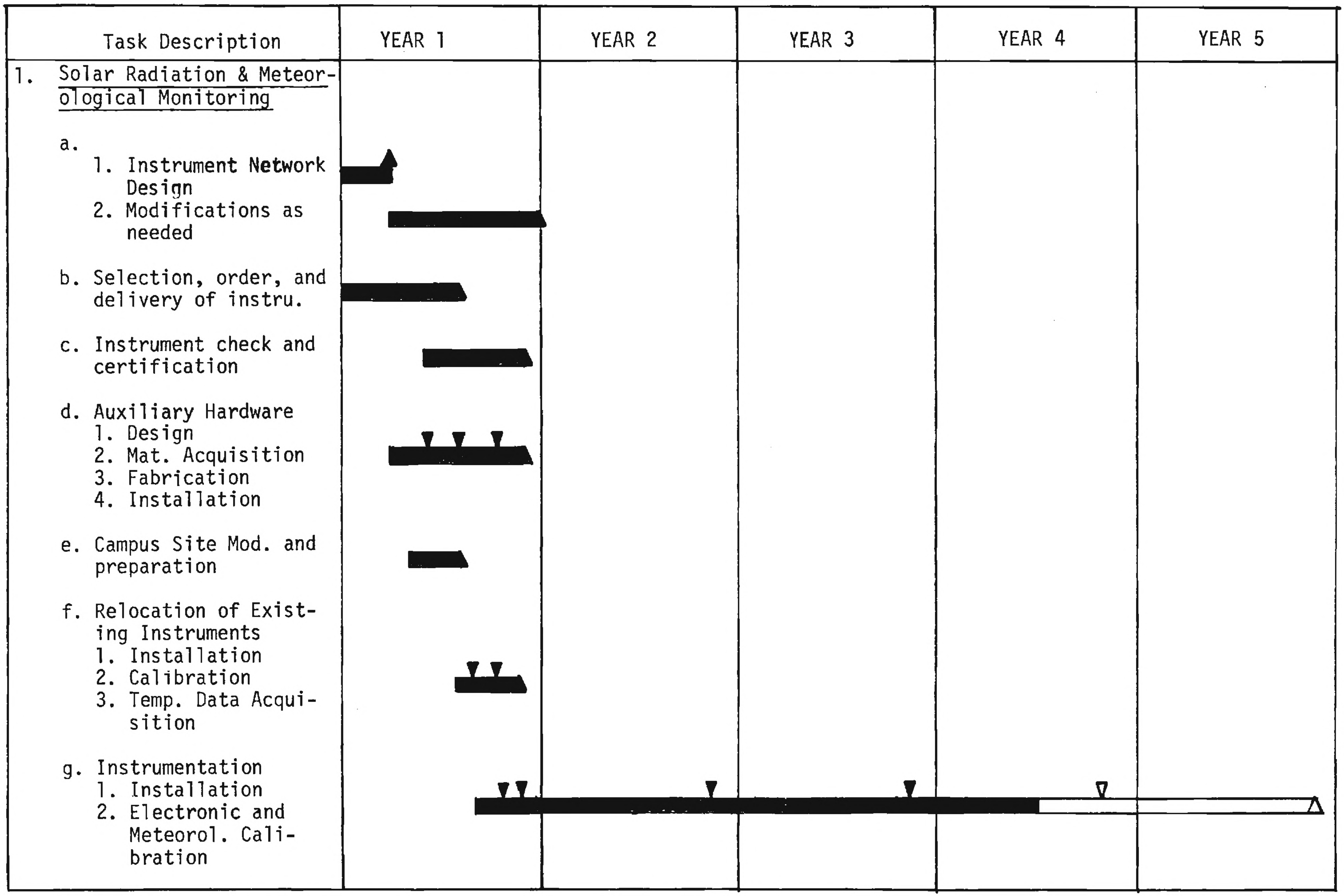
Urban/rural comparisons between Georgia Tech and Shenendoah continue. Intersite differences during a three week study at St. Croix, U.S. Virgin Islands West Indies Laboratory indicate consistent inter-site differences in that tropical regime as those found on the mainland U.S. These results will also be reported at the April 1981 Georgia Academy of Sciences, by the student who conducted the St. Croix tests. A copy of that presentation is attached.

MILESTONES AND BUDGET

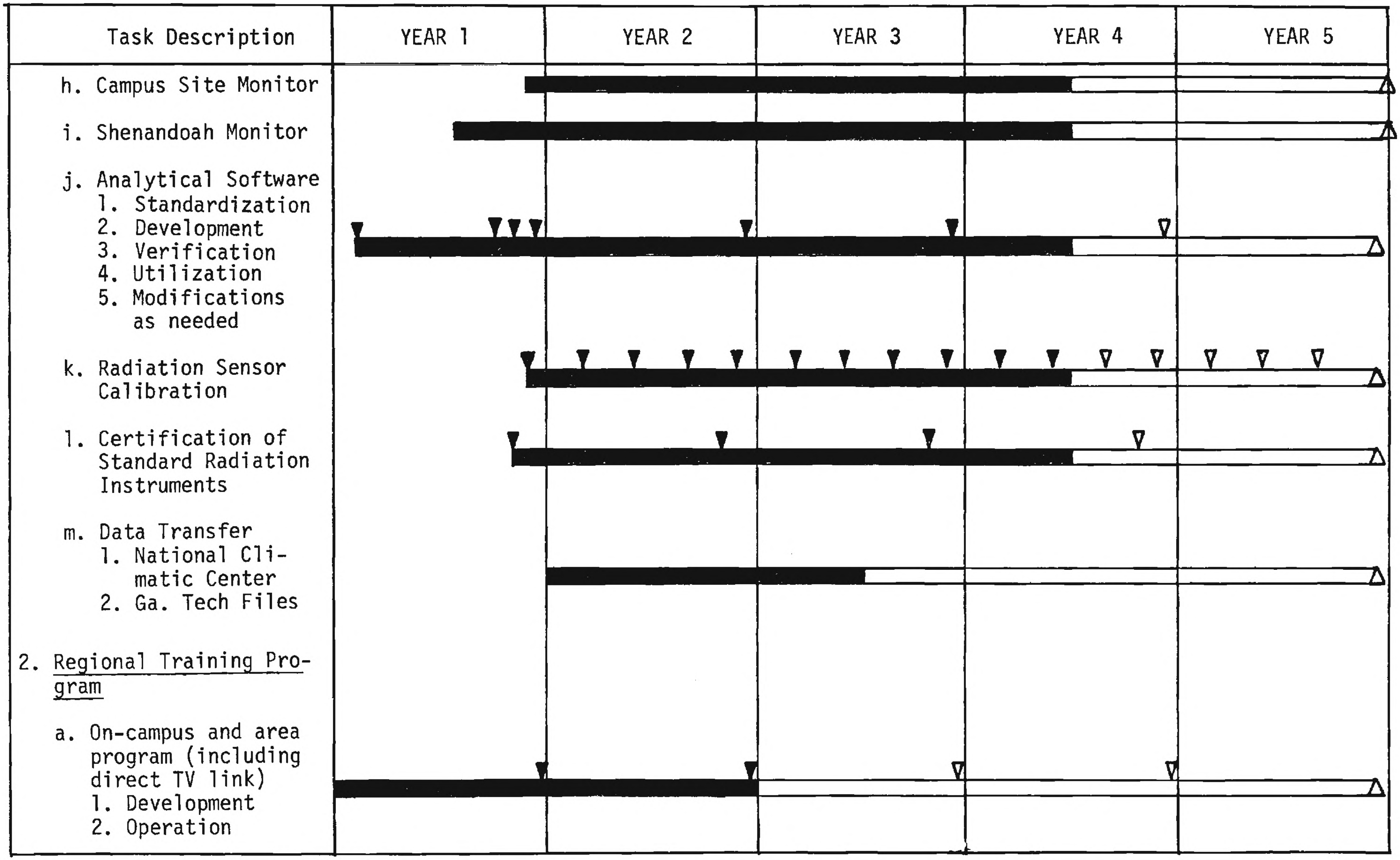
Expenditures in the current project year, through December 1980, total approximately $105,000, which is only 5% over the linear projection project expenditure plan.

A detailed milestone and progress chart is attached.

Milestone Chart



Milestone Chart (Cont'd.)



Milestone Chart (Cont'd)

Task Description	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
b. Southeast Region Training Program 1. Develop regional arrangements 2. In-persion traveling regional courses 3. Regional TV training courses					
3. <u>Instrument and Monitoring Technical Research</u>					
a. Solar Energy Site Influence					
b. Urban/Rural Comparisons					
c. Analysis of Regional Relations					
d. Portable Monitoring Units (PMU) for Training and Regional Study 1. Design (PMU's) 2. Instrument acquisition 3. Construction and testing 4. Cycle of field operation and training courses		Unit 1	Unit 2	Unit 3	
e. On-campus operation of the LBL Circumsolar Telescope					

Milestone Chart (cont'd)

Task Description	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
f. Automatic sun photometer					
1. Research and development					
2. Testing and operation					
g. Automatic cloud cover camera					
1. Research and development					
2. Testing and operation					
4. <u>Reports and Review Meetings</u>					
Technical Status Reports					
Review Meeting					
Technical Progress Reports					

THE JACKSON STATE UNIVERSITY DIVISION OF NATURAL SCIENCES

AND

THE GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF GEOPHYSICAL SCIENCES

ANNOUNCES

A SHORT COURSE

Urban and Regional View on Air Resources

MARCH 23-27, 1981

DIVISION OF NATURAL SCIENCES

SHORT COURSE DESCRIPTIONS

MESOSCALE DYNAMIC METEOROLOGY

Global distribution of temperature, wind and pressure in the atmosphere. Qualitative discussion of the main dynamic features of the earth's boundary layer. Rainstorms, windstorms, and other mesoscale phenomena.

INSTRUCTOR : Franco Einaudi, Ph.D.
TIME : Monday, March 23, 1981, 9:00 a.m. - 12:00 noon
PLACE : New Science Building, Room 228.

OPTICAL PROPERTIES OF AEROSOL

Radiative transfer in the atmosphere, absorption and scattering by the atmospheric particulates, atmospheric visibility and optical effects.

INSTRUCTOR : G. W. Grams, Ph.D.
TIME: : Tuesday, March 24, 1981, 9:00 a.m. - 12 noon
PLACE : New Science Building, Room 228.

AIR POLLUTION METEOROLOGY

Vertical temperature and wind structure, topographic effects, natural removal processes, atmospheric dispersion of stack effluents, air pollution climatology, meteorological management of air pollution.

INSTRUCTOR : C. G. Justus, Ph.D.
TIME : Wednesday, March 25, 1981, 9:00 a.m. - 11:00 a.m.
PLACE : New Science Building, Room 228.

METEOROLOGICAL IMPACT ON SOLAR AND WIND ENERGY

Solar radiation instrumentation, measurement and calibration techniques, atmospheric attenuation, effects of clouds and turbidity. Meteorological factors of wind energy system design, performance, evaluation and siting.

INSTRUCTOR : C. G. Justus, Ph.D.
TIME : Wednesday, March 25, 1981, 2:00 p.m. - 3:00 p.m.
PLACE : New Science Building, Room 228.

AIR POLLUTION CHEMISTRY

Sources, sinks, transformations and transport of chemical pollutants and their impact on human welfare. Laboratory studies, field measurements, and numerical modeling in air pollution chemistry.

A. OVERVIEW

INSTRUCTOR : C. S. Kiang, Ph.D.
TIME: : Thursday, March 26, 1981, 9:00 a.m. - 11:00 a.m.
PLACE : New Science Building, Room 228.

B. LABORATORY STUDIES

INSTRUCTOR : John Hall, Ph.D.
TIME : Thursday, March 26, 1981, 2:00 p.m. - 4:00 p.m.
PLACE : New Science Building, Room 228.

C. FIELD MEASUREMENT

INSTRUCTOR : Luther Roland, Ph.D.
TIME : Friday, March 27, 1981, 9:00 a.m. - 11:00 a.m.
PLACE : New Science Building, Room 228.

SHORT COURSE FACULTY

EINAUDI, F. (Cornell University) Geophysical fluid dynamics, stability theory, mesoscale and microscale dynamics, wave turbulence interactions.

GRAMS, G. W. (Massachusetts Institute of Technology) Atmospheric aerosols, remote sensing (lidar), satellite observations, atmospheric optics and radiation, climate dynamics.

HALL, J. H., Jr., (Harvard University) Matrix-isolation-infraredlaser Raman spectroscopy; electronic structure theory and laser induced multiphoton processes.

JUSTUS, C. G. (Georgia Institute of Technology) Atmospheric dynamics, wind and solar energy, solar radiation, atmospheric turbulence, and diffusion.

KIANG, C. S. (Georgia Institute of Technology) Chemical and physical properties of atmospheric aerosols, nucleation processes, gas-aerosol-dynamical modeling, environmental science and planning.

LEWIS, L. (SUNY at Albany) Physical meteorology, solar and atmospheric radiation, solar energy, air pollution.

ROLAND, L. (SUNY at Albany) Atmospheric chemistry, physical meteorology, liquid and gas-phase organic analysis, gas chromatography.

SPECIAL INSTRUMENT EXHIBIT

A mobile van exhibit will include air pollution sampling equipment and instruments for recording vertical temperature and wind structure.

PARTICIPANTS

For chemistry credit, enroll in Special Topics (Chem 570), 1 hr.; Pre-requisite: Physical Chemistry.

For meteorology credit, enroll in Seminar in Meteorology (SCI 592W), 1 hr.; Pre-requisite: Dynamic Meteorology

For no credit, by permission.

Persons involved in state and federal environmental laboratories, university scientists, industrial scientists, advanced undergraduate students, and graduate students are invited to enroll in this course.

COST

For credit (1 hr.) - $45.00
For non-credit - $25.00

FOR ADDITIONAL INFORMATION

For Technical Information contact:

Dr. Keith Johnson
Meteorology Program
Just Science Hall
Jackson State University
Jackson, Mississippi 39217
601-968-2566

For Enrollment Information contact:

Ms. Regina Graves
Department of Chemistry
Jackson State University
Jackson, Mississippi 39217
601-968-2566

Operations of the Georgia Tech Tethered Balloon System At Jackson State University

A newly acquired tethered balloon system has been used to obtain profiles of atmospheric variables during a site visit by our Mobile Atmospheric Research Vehicle (MARV) to Jackson State University (JSU) in Jackson, Mississippi. The tethered balloon system, trademark TETHERSONDE, is marketed by Atmospheric Instrumentation Research, Inc. (AIR). The principal components of the TETHERSONDE system are: 1) an airborne sensor package which senses pressure, dry bulb temperature, wet-bulb depression, wind direction and speed, and which transmits the sensed values to the ground via FM telemetry,

2) an aerodynamically shaped balloon (blimp) which carries the sensor package aloft,

3) a variable speed, reversible winch which controls the rate of ascent or descent of the balloon via control of tether line, and

4) a ground station which receives and processes the telemetry signal from the airborne sensor package.

Temperature and wet-bulb depression are measured by a matched set of bead thermistors which form the sensing elements of a aspirated psychrometer. Pressure is measured by an aneroid barometer. A three cup anemometer mounted atop the sensor package measures wind speed. Wind direction is sensed by observing the orientation of the balloon, i.e., the balloon is used as a wind vane. When the balloon is properly tethered, it orients into the wind quite effectivley. A magnetic compass in the sensor package detects the orientation of the package relative to magnetic north. All measured values are sent to the ground where they are converted to an analog voltage and to digital data that are displayed via light-emitting diodes (LED). The digital data was processed by a small printing calculator.

In addition to the measured variables, pressure (P), temperature (T), wet-bulb depression (ΔT_w), wind speed (U), and wind direction (WD), the calculator allowed the computation of height (z), relative humidity (RH), water vapor mixing ratio (MR), and potential temperature (POT) from the measured values.

Figures 1 and 3 show the profiles of the measured variables from two flights taken during the JSU visit. Figures 2 and 4 show the profiles of the derived variables from the same two flights. The first flight was taken on 3/24/ 81 1800-1830 CST and is denoted as "Profile 1". The second flight was taken on 3/26/81 1625-1700 CST and is denoted as "Profile 3". The ordinate on all graphs is the height above the surface in meters. The abscissa on all graphs is a relative scale which allows one to read all variables directly. Temperature (°C) is displayed on both the measured and the derived data profiles as a reference. Pressure (mb) has been modified by a factor of 10^{-2} for convenience. Wind direction (0 - 360) has been modified by a factor of 10^{-1} and is displayed in a novel manner. Since the winds were predominately out of the North, directions between 0 and 90 (0 and 9 on graph) are displayed as directions between 360 and 450 (36 and 45 on graph). All other variables are displayed without modification, save potential temperature which is displayed in degrees Celsius rather than the usual degrees Kelvin.

The flight taken on 3/24, denoted here by JSU-1 and shown in Figures 1 and 3, produced smooth profiles of all variables. At the time of flight, the surface temperature was about 15°C with winds out of the North. A height of about 300m was obtained before descending. Maximum wind speeds were less than about 3.5m/sec within the layer. The relative humidity was fairly constant throughout the layer at about 35-40%. The temperature profile showed a lapse rate of about $\Delta T/\Delta z \sim \frac{-2.0}{300} = -6.7°C/km$. This is close to the value for the U.S. Standard Atmosphere.

The flight taken on 3/26, denoted here by JSU-2 and shown in Figures 3 and 4, produced profiles which were not as smooth as those obtained for JSU-1. The surface temperature at time of flight was about 22°C, much warmer than that on 3/24. The winds had shifted to predominately NNE and had become more variable. Conditions were much more turbulent on this day than on 3/24. Maximum wind speeds up to about 6m/sec existed in a layer stretching from the surface to about 350m. The relative humidity profile shows some interesting behavior. Its value is lower than for JSU-1 but is not nearly as constant throughout the layer. The temperature profile produced a lapse rate of $\Delta T/\Delta z \sim \frac{{}^{-}3.3}{350} = {}^{-}9.4°C/km$ which is closer to the dry adiabatic condition than for JSU-1, signifying drier air for JSU-2.

The above discussion and Figures 1-4 are presented here to serve as examples of the type of data retrievable with our tethered balloon system. The profiles represent the raw data. No in-depth quality control or quantitative analysis of these initial and limited data has been attempted.

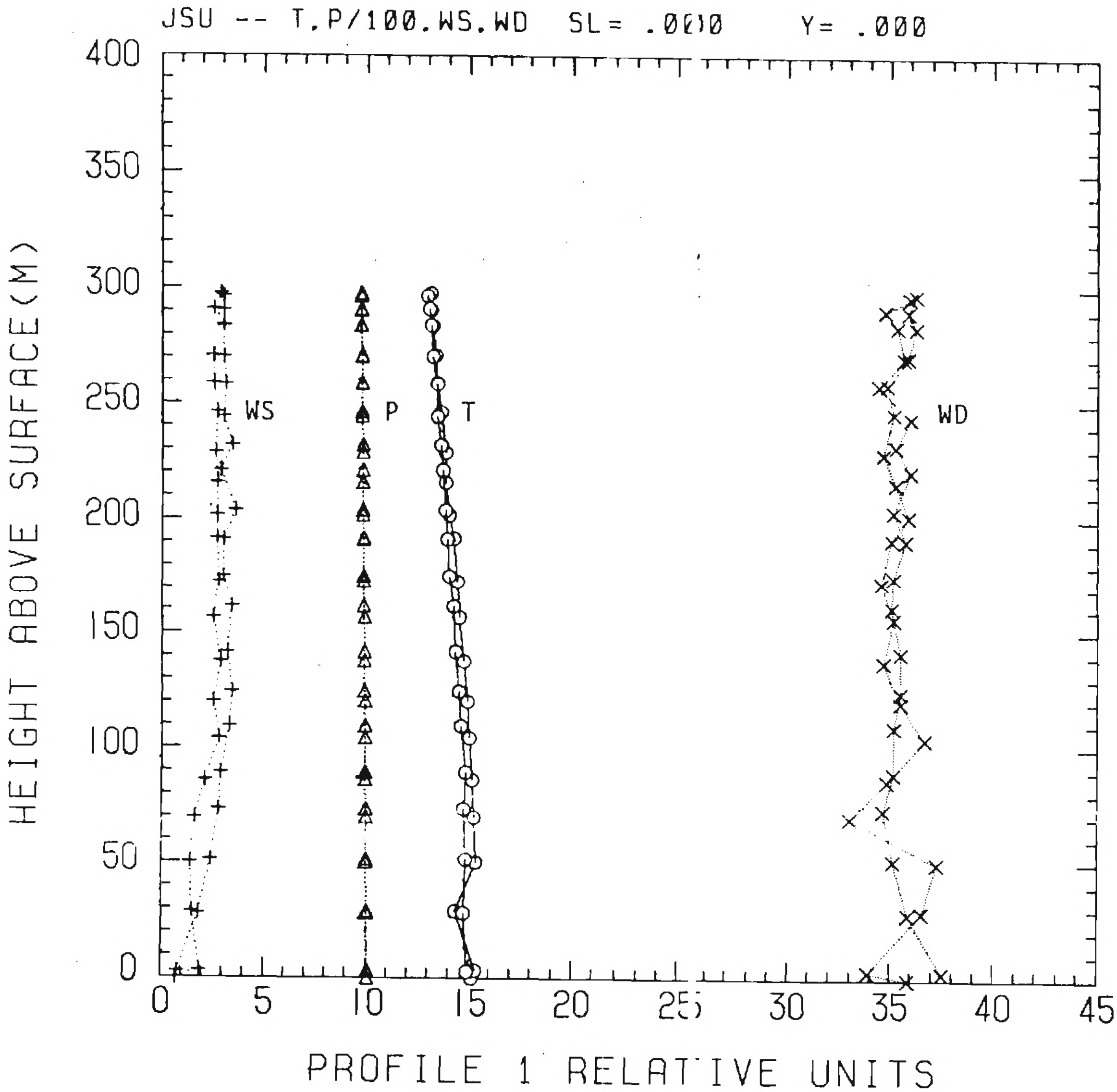


Figure 1. Profiles of wind speed, WS (m/sec)---+; pressure P(10^{-2}mb)--Δ; temperature, T(°C)--0; and wind direction WD (10^{-1} deg)--x taken on 3/24/81 1800-1830 CST at Jackson State University. All variables may be read directly off the abscissa. See text for explanation of wind direction scale.

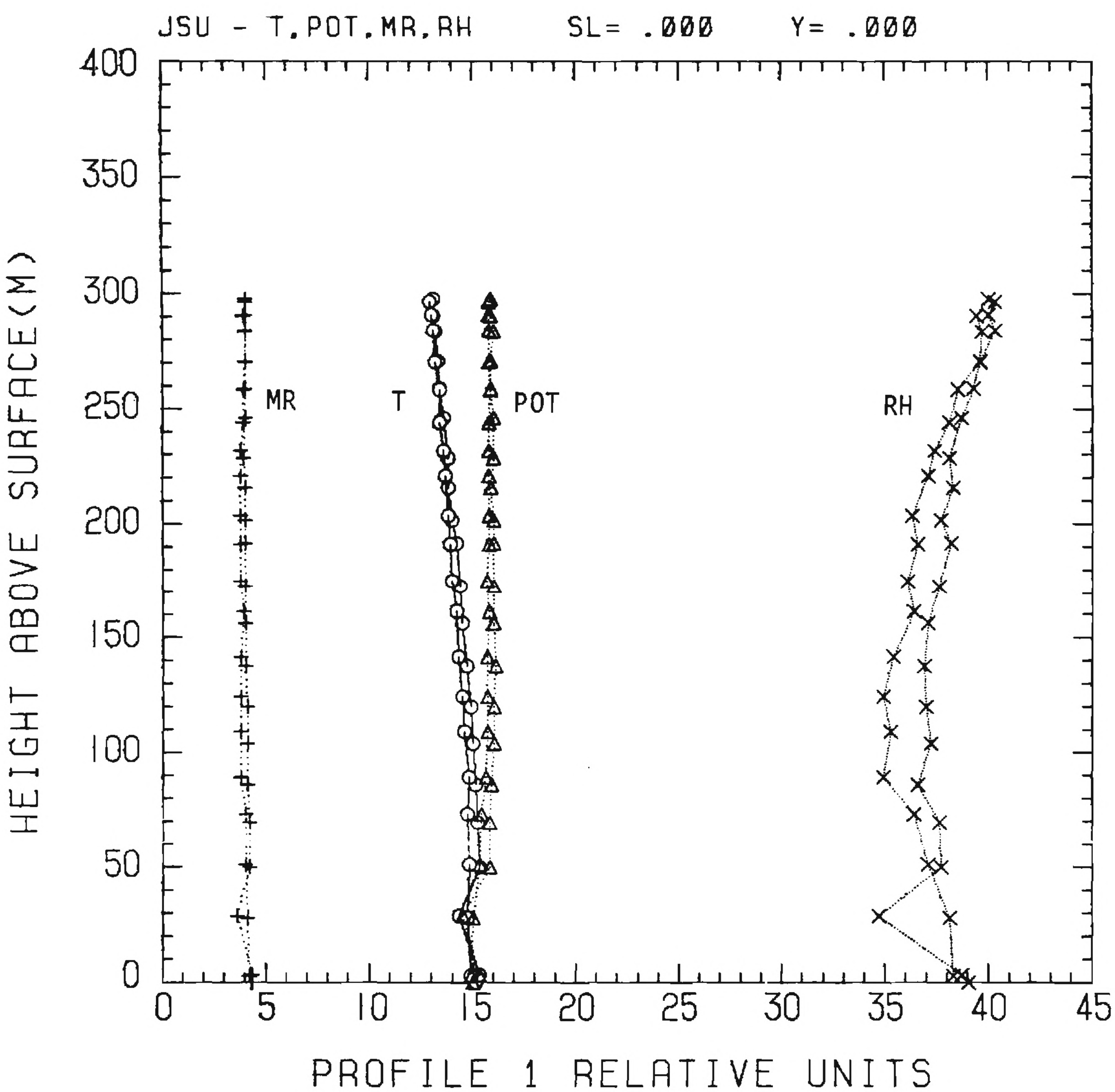


Figure 2. Profiles of water vapor mixing ratio, MR(g/kg)--+; temperature T (°C)--O; potential temperature, POT (°C)--Δ; and relative humidity, RH(%) taken on 3/24/81 1800-1830 CST at Jackson State University. All variables may be read directly off the abscissa.

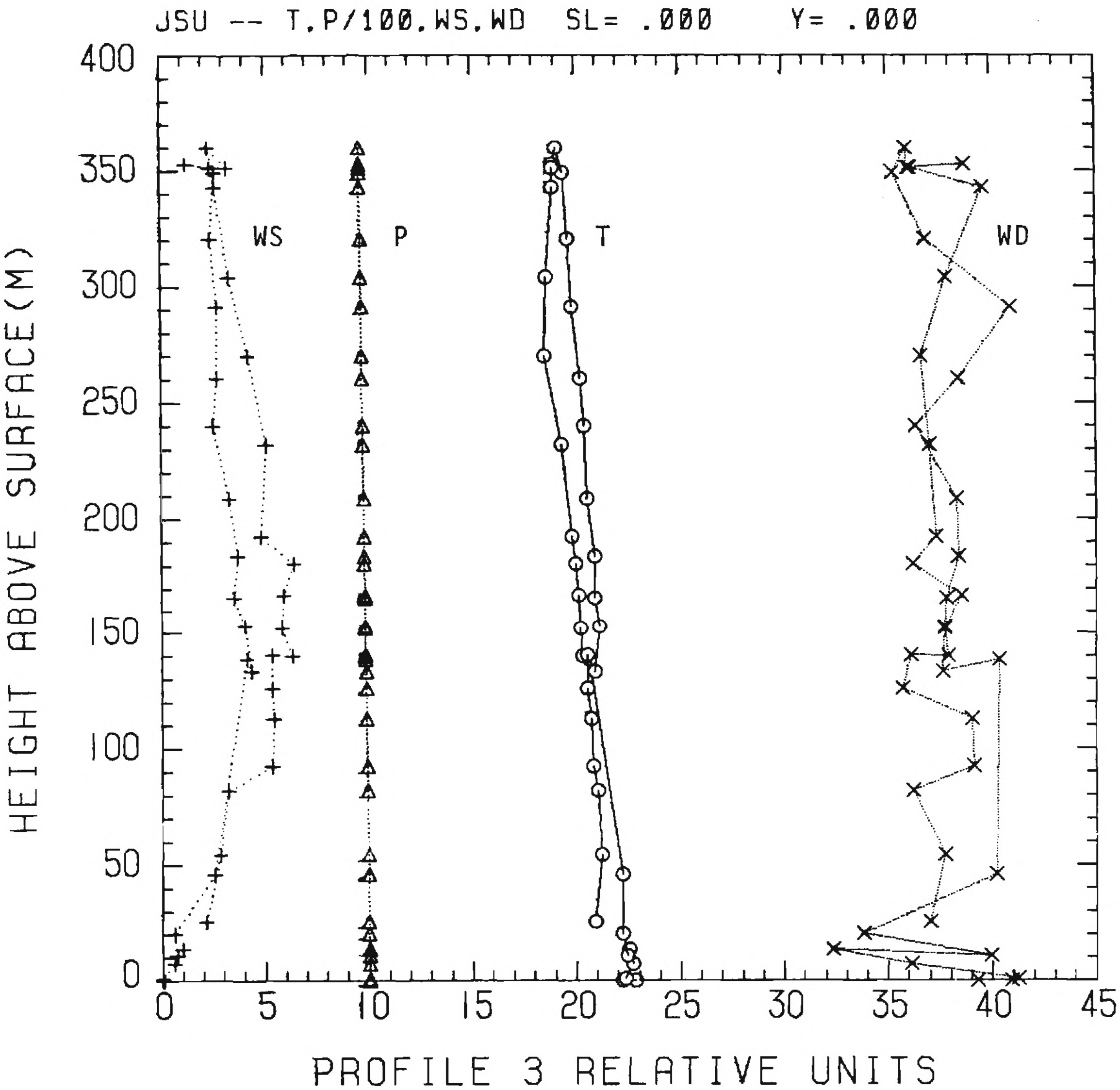


Figure 3. Profiles of wind speed, WS(m/sec) --+; pressure P(10^{-2}mb)--Δ; tmeperature T(°C)--0; and wind direction WD(10^{-1} deg)--x taken on 3/26/81 1625-1700 CST at Jackson State University. All variables may be read directly off the Abscissa. See text for explanation of wind direction scale.

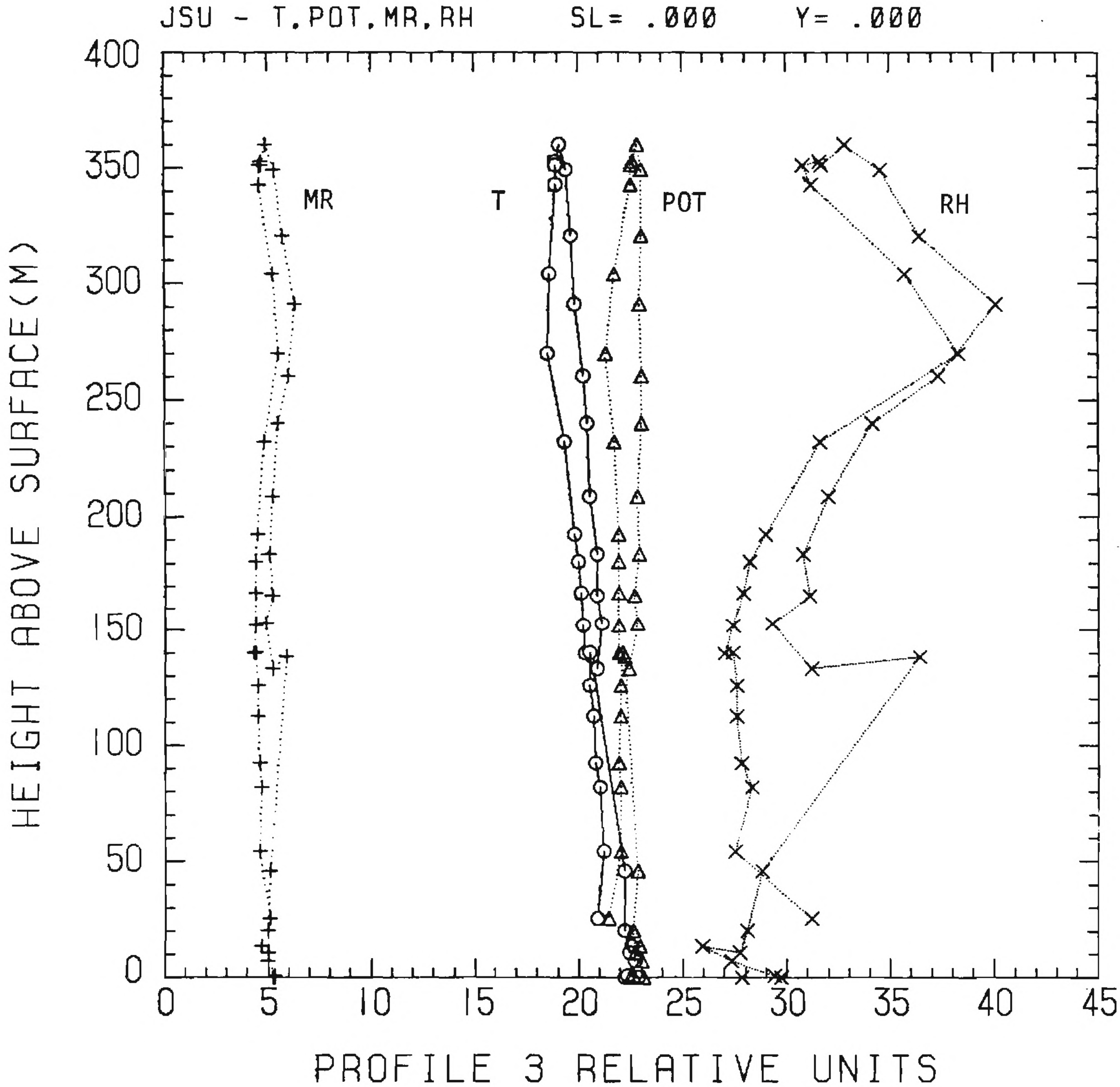


Figure 4. Profiles of water vapor mixing ratio, MR(g/kg)--+; temperature T(°C)--O; potential temperatures, POT(°C)--Δ; and relative humidity, RH(%) taken on 3/26/81 162501700 CST at Jackson State University. All variables may be read directly off the abscissa.

AN ASSESSMENT OF THE MONITORING AND MODELING NETWORK IN THE SOUTHEASTERN UNITED STATES

by Joseph Sherry

In 1979, a study was conducted by Hay and Suckling, in British Columbia and Alberta Canada, to develop a method to extrapolate spatially daily global solar radiation measurements. The method assumes that the relationship between solar radiation variability and distance between stations is independent of both location (homogeneous) and direction (isotropic). Hay and Suckling were able to show that isotropy had limited application but were unable to test the assumption of homogeneity because of the limited geographical area of the study. In 1980, the variations of hourly and daily global solar radiation measurements were studied in Georgia in the United States and in St. Croix in the U.S. Virgin Islands. Agreement was found with the work of Hay and Suckling giving credence to the assumption of homogeniety. Based on the assumption of homogeneity and isotropy the solar radiation monitoring and modeling network in the southeastern United States was examined and found to have a 25% error tolerence in spatially extrapolated global solar radiation.

The purpose of this paper is to examine the ability of the present solar radiation network, in the southeastern United States, to determine reasonably accurate approximations of the amount of solar radiation received at the earth's surface. With the advent of the fuel crisis much attention has recently been given to alternate energies, such as the use of solar energy in home and water heating. In order to determine the feasibility of using solar energy and to design solar equipment, long term, detailed, and accurate solar radiation data is required. These data would include frequency distributions and mean hourly and daily direct, diffuse and global solar irradiances for both horizontal and inclined surfaces along with expected degree of error. In locations where hourly solar radiation measurements do not exist, modeled estimates of solar radiation can be made using meteorological data. The advantage of modeled solar radiation data is that the past record of meteorological data is quite long and the disadvantage is that modeling error exists that reduces the accuracy of the calculated solar radiation data.

The solar radiation network in the United States is composed of 39 NOAA monitoring stations, 8 university monitoring stations, 26 rehabilitated solmet data control stations and 222 solmet derived data stations. The U.S. monitoring network including both the NOAA and university stations represents approximately one monitoring station for every 200,000 km^2 which provides the same spatial density as Canada's 52 station network. Twenty five of NOAA's thirty nine stations began monitoring hourly global radiation in January 1977, with the remaining fourteen stations beginning at a later date. The ten NOAA stations measuring hourly diffuse radiation began monitoring on or after May 1977. Hourly direct radiation measurements began in 1978 at most stations. The university monitoring network measures hourly global, diffuse and direct solar radiation and presently has about a two year record. The twenty six rehabilitated solmet data control stations have a record of hourly global radiation measurement that varies but is generally from July 1952 through December 1975, from which a global solar radiation regression model was developed and is now being used at these rehabilitated solmet data control stations as well as the solmet derived data stations. The solmet derived data stations generally have a calculated global solar radiation record beginning in January 1952. It is from the meteorological record and the regression model developed at the 26 solmet data control stations that global radiation is derived at these sites since they have no radiation monitoring per se. It should be noted that according to NOAA, "...many instrumental and procedural errors have produced highly suspect data" (NOAA 1980). Also it should be noted that both the NOAA and university monitoring networks are having funding difficulties that may soon cause them to cease operations.

A method was developed by Hay and Suckling (1979) to extrapolate spatially both daily global solar radiation measurements and calculations. This extrpolation is dependent on the density of the stations, the variability and coherence in the solar radiation field and the accuracy of the measured values. The spatial coherency was found by plotting the coefficient of variability versus distance between stations for nine solar radiation monitoring stations in British Columbia and Alberta Canada for the period 1968 to 1972 (see Fig.1), the coefficient of variability being

$$C_v = \frac{\text{Root mean square error}}{\text{Average}} * 100 = \frac{\sqrt{\sum(GL_1-GL_2)^2}}{0.5\sum(GL_1+GL_2)} * 100$$

where GL_1 and GL_2 are the global radiation measured at two stations separated by a known distance. This method assumes that the relationship between solar radiation variability and distance between stations is independent of both location (homogeneous) and direction (isotropic). Suckling and Hay found that the assumption of isotropy is not always met due to selected synoptic weather conditions. Fortunately, however, it was found that for extrapolation errors below ±20 percent the differences due to synoptic weather types is not well developed and it is not until a station spearation of 200 km that the differences due to synoptic types become well developed. Also it was concluded by Suckling and Hay that the incidence of some anisotropy does not negate the conclusion but only requires certain limits. As to the accuracy of solar radiation values Suckling and Hay considered calculated daily global solar radiation values in there study to have approximately a ±15% calculation error and the estimate of variability resulting from the regressions, at the rehabilitated solmet data control stations, expressed as the coefficient of variability, range from 5 to 18% for daily global values (Solmet 1979). For the purpose of this study a 15% calculation error will be used.

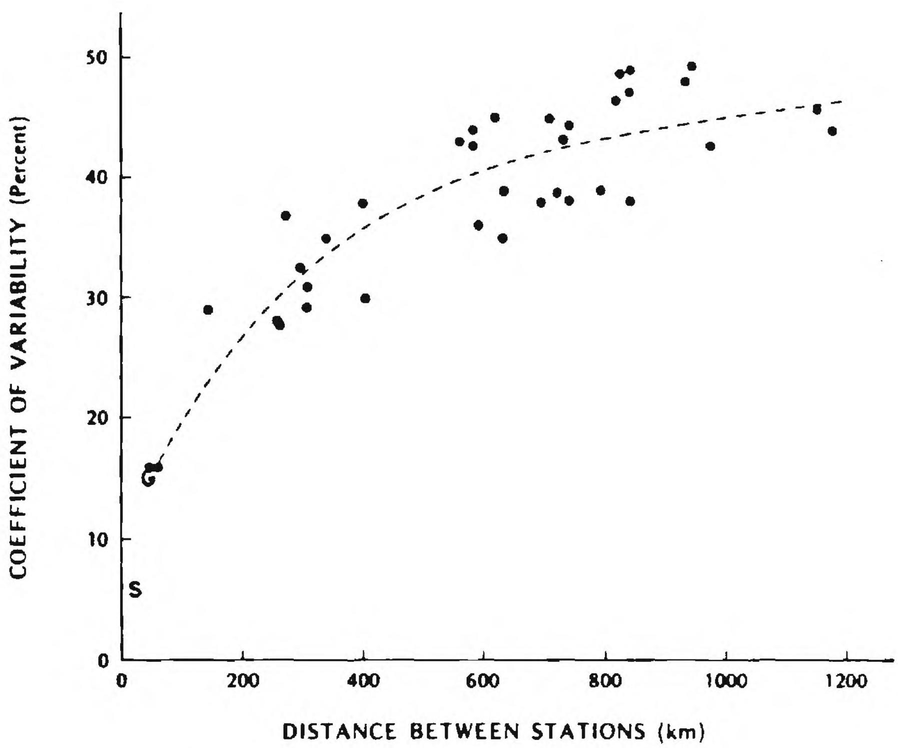


Figure 1. The dots(•) denote the relationship between the coefficient of variability of differences in daily values of global solar radiation for pairs of stations and the distance between station pairs for locations in British Columbia and Alberta. The G and S show the same relationship for stations in Georgia and St. Croix respectively.

During the month of August 1980 two studies were conducted to test the homogeneous assumption used by Suckling and Hay. One of these studies took place in St. Croix in the U.S. Virgin Islands and involved global solar radiation measurements taken at one control and four remote sites, separated by an average distance at 17.5 km and covered a time period of 15 days. The other study took place in the state of Georgia in the United States and involved global solar radiation measurements taken at one control and one remote site, separated by a distance of 50 km and covered a time period of 28 days. The coefficient of variability was calculated for 10 min., hourly, and daily intervals except in Georgia where only hourly and daily intervals were used. Table 1 gives the values obtained for C_V and clearly show a trend of decreasing C_V with increasing time intervals. When the daily C_V values obtained in St. Croix and Georgia are included with the Canadian data in Fig.1 good agreement is obtained giving credence to the assumption of homogenuity at least for relatively small station spearation. Since no synoptic patterns developed at these locations during the time of this study and because the station separations were well below 200 km nothing can be added to support or challenge the assumption of isotropy.

Table 1.

Location	Distance between stations	C_V (10 min)	C_V (hr)	C_V (day)
St. Croix	17.5 (ave)	33%	25%	6%
Georgia	50.0		34%	15%

Figures 2-5 are plots of the hourly and daily global radiation measured at the control sites versus the remote sites for both St. Croix and Georgia. These Figures show graphically the increase in scatter with both increase in separation of station and decrease in time interval.

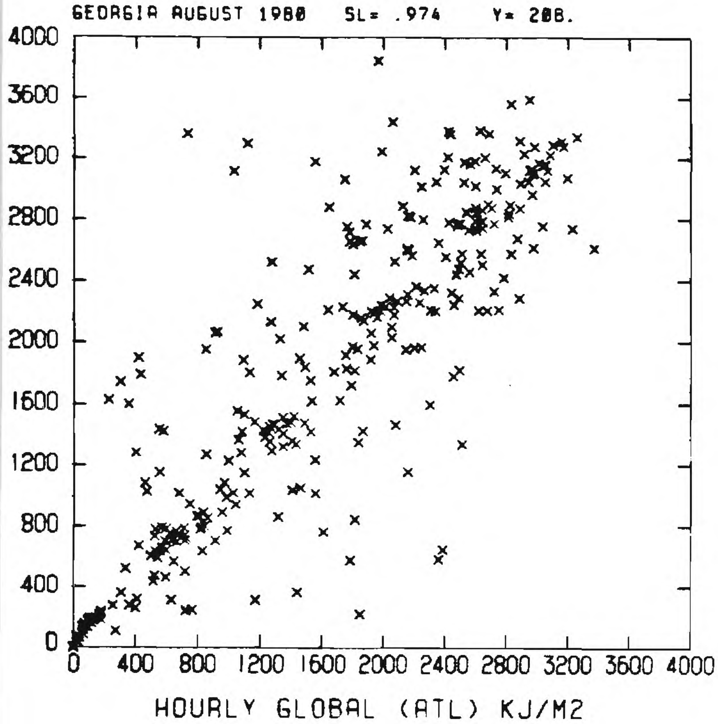


Figure 2

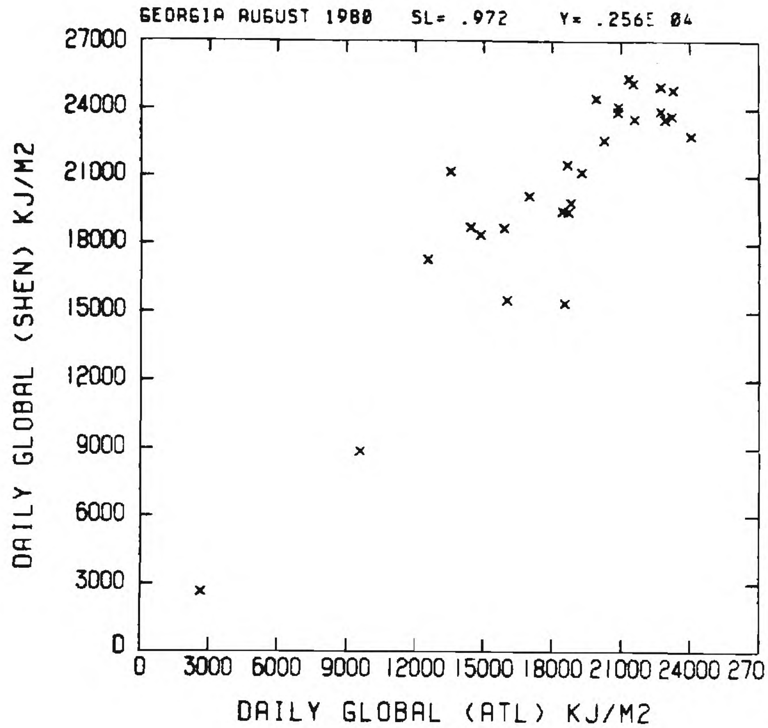


Figure 3

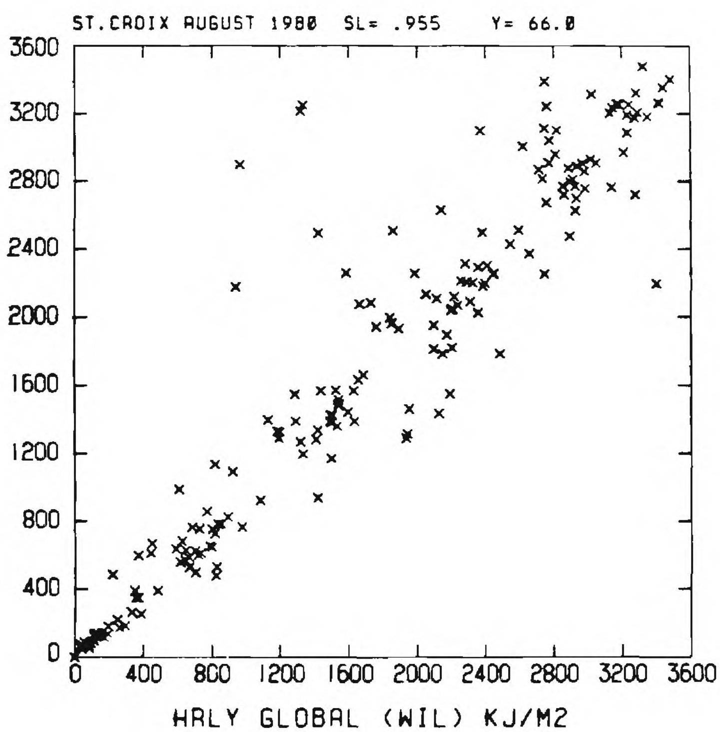


Figure 4

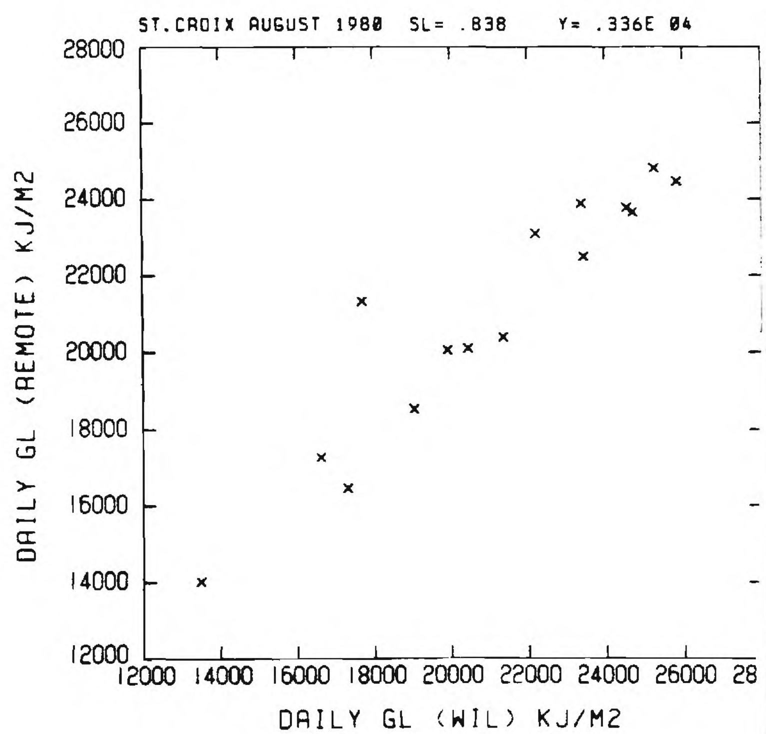


Figure 5

Figures 2&4. Represent the relationship between hourly global solar radiation for pairs of stations in Georgia and St. Croix respectively.

Figures 3&5. Represent the relationship between daily global solar radiation for pairs of stations in Georgia and St. Croix respectively.

The agreement of the limited Georgia and St. Croix daily C_v data with that of the Canadian data, allows us to assume homogeneity and use Fig.1 to obtain extrapolation errors for daily global radiation for the southeast region. An extrapolation over distances of 50 km, 100 km, 180 km will produce average errors in solar radiation estimates due to extrapolation of ±15%, ±20% and ±25% respectively on a daily basis. Fig.6 displays the result of using only solar radiation monitoring stations along with an extrpolation error of 15%, but this obviously is inadequate to give proper coverage of the region. Fig.7 uses the same stations as Fig.6 but allows for a 25% error and again the coverage is found to be inadequate. If we now look at the Solmet derived data stations and assume a ±15% modeling error for daily global solar radiation calculations and a 20% extrapolation error then the resulting root mean square error will be 25%. Fig.8 represents this 25% error for modeling stations only and shows an improvement in the coverage, yet still major gaps exist. When both monitoring and modeling stations are considered together with an error of 25%, the southeast region is nearly completely covered. (see Fig.9)

In conclusion it is found that the present solar radiation network in the southeast region, consisting of both monitoring and measuring stations comes very close to covering the area with a maximum of a ±25% error in daily global solar radiation values. In a few areas coverage could be improved with a few well placed monitoring or modeling stations. Since the coefficient of variability increases greatly with decreasing time interval, it is not thought that a scheme to extrapolate hourly global radiation values would maintain an exceptable degree of error unless the solar radiation network were dramatically increased or satellite-solar radiation estimation techniques are developed. In light of present federal budget cuts it is only hoped the present network will not be decreased in size. Also because the data indicate the assumption of homogeneity to be correct, this study could be duplicated for all regions in the United States in order to evaluate the entire solar radiation network.

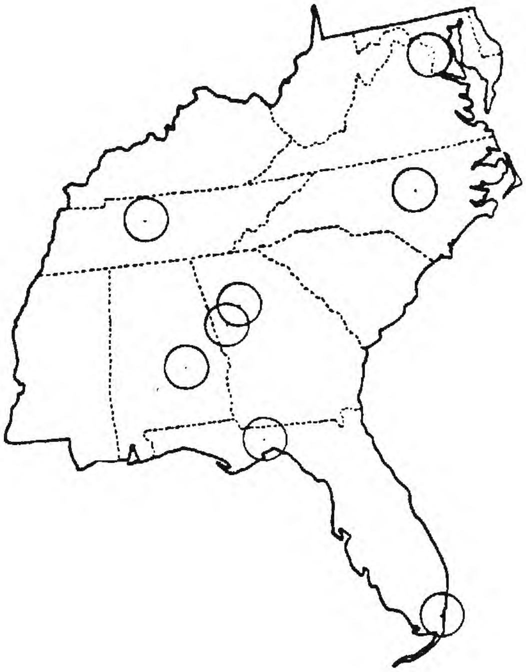


Figure 6. the area inside the circles represents global solar radiation spatial coverage by monitoring stations for a 15% error tolerance.

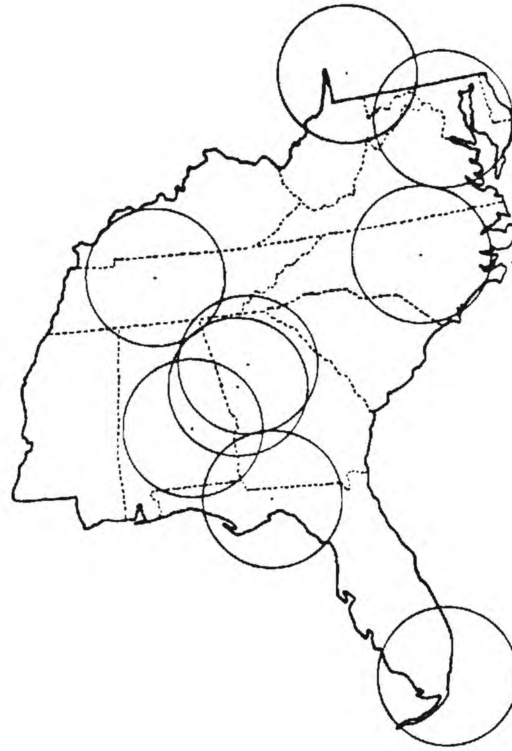


Figure 7. The area inside the circles repesents global solar radiation spatial coverage by monitoring stations for a 25% error tolerance.

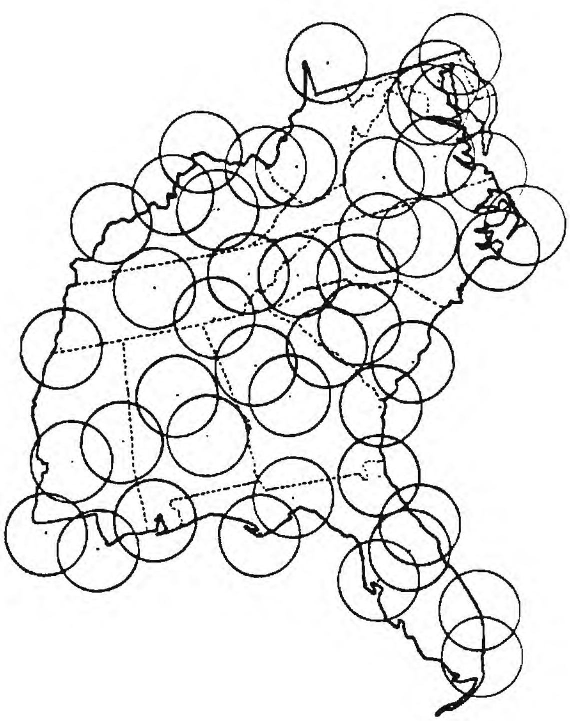


Figure 8. The area inside the circles represents global solar radiation spatial coverage by modeling stations for a 25% error tolerance.

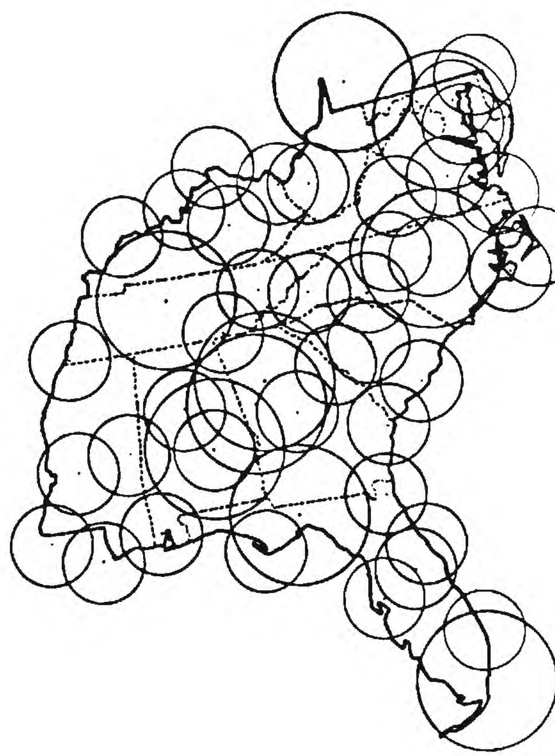


Figure 9. The area inside the circles represents global solar radiation spatial coverage by monitoring and modeling stations for a 25% error tolerance.

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ORO/5604-81-3

PROGRAM FOR SOLAR ENERGY METEOROLOGICAL RESEARCH AND TRAINING SITE (REGION 3)

Quarterly Technical Status and
Contract Management Report

C. G. Justus, Principal Investigator

Georgia Institute of Technology
Atlanta, GA 30332

July 1981

Report Period April 1, 1981 - June 30, 1981

PREPARED FOR THE UNITED STATES
DEPARTMENT OF ENERGY

DIVISION OF DISTRIBUTED SOLAR TECHNOLOGY

UNDER GRANT FEFOG05-77-ET20153

Under Georgia Tech Project E-16-C03

1. PROJECT OBJECTIVES

This broad program of solar energy and meteorological monitoring, training, and research has the following main objectives for the proposed 5 years duration:

(1) to provide for the Southeast Region (Region 3) a set of continuously monitored and quality controlled data on solar radiation and atmospheric phenomena related to solar energy collection, conversion, and storage, and to relate these to the extensive ongoing solar energy research and engineering projects carried out by Georgia Tech and in the Southeast Region.

(2) by analysis of monitoring results at two sites (on campus, adjacent to the Georgia Tech thermal Test facility and off-campus adjacent to the Shenandoah Solar Total Energy Site), determine: a) optimum siting of solar radiation and meteorological monitoring instruments relative to solar energy systems to provide the most representative site data with the least influence from the solar collector systems, b) adequacy and representativeness for the Southeast Region of various methodologies for relating easily measured phenomena (minutes of sunshine, cloud cover, etc.) to engineering quality solar radiation data (direct, diffuse, and global insolation, etc.).

(3) to establish and maintain a training program which will allow: a) undergraduate and graduate engineering students, through elective or minor courses, to become informed in the areas of meteorology and atmospheric science as they relate to solar and wind energy, b) graduate students in the atmospheric sciences to become informed of the specific requirements of monitoring, analysis, interpretation and presentation of meteorological information related to engineering aspects of solar and wind

energy, c) professionals in various fields, through short courses and seminars, to become familiar with the new and rapidly developing aspects of solar energy engineering and technology, especially the radiation monitoring and meteorological aspects of this field.

(4) through cooperation in the 3/2 dual degree program, the National Consortium for Graduate Degrees for Minorities in Engineering and other academic programs, enhance the opportunities for minorities (especially Black American and Puerto Ricans) and women in the solar energy engineering and technology field.

(5) instrumentation and monitoring techniques research and development to enhance the engineering applicability of the solar radiation and meteorological monitoring and to provide better instructional tools through low cost instrument systems for educational purposes.

(6) to investigate, with the fixed site instruments and the portable monitoring units (PMU's), the influence of urban haze and aerosols as well as the high levels of natural turbidity which occur in parts of the Southeast region, and with the PMU's to sample the effects on solar radiation of a wide variety of geography (which spans coastal, piedmont plains, and mountainous within the Southeast region).

2. PROJECT PLAN

A. Research Approach and Definition of Tasks

The proposed project plan is divided into three major tasks, each with several subtasks, as follows:

Task 1: Solar Radiation and Meteorological Monitoring Program

This task includes acquisition, initial calibration, and installation of the solar radiation and meteorological instrumentation at the on-campus (Solar Thermal Test Facility/Wind Turbine Test Facility) site and the off-campus (Shenandoah Georgia Solar Total Energy Project) site. Existing and new instrumentation at these sites will be combined and interfaced through data loggers and magnetic tape recording into a form which can be processed, summarized, and formatted by the main campus computer (CYBER 70/74 system). Annual calibration of the instrumentation, against national standards where appropriate, will be carried out, as well as more frequent field calibration of the radiation monitoring instruments. A carefully monitored program of daily instrument inspection and routine maintenance will also be carried out. The detailed outline of the various subtasks under Task 1 is as follows:

a. Based on the proposed variables to be monitored, the Instrumentation Network Design will be laid out using equipment assigned by Georgia Tech for use on this program and additional units to be purchased with the sponsor's approval.

b. Using the preliminary network design, the Selection, Order, and Delivery will be based on recommendations made at the preliminary review meeting of all of the principal investigators.

c. Before an instrument or support unit is put into service, each piece of equipment will be examined and subjected to an Instrument Check and Certification for conformation to Georgia Tech and vendor specifications.

Instruments which fail to pass inspection will be returned to the vendor for replacement.

d. The design, fabrication, and installation of the Auxiliary Hardware which will house and/or support the instrumentation will be according to recommendations in the above articles, of the respective vendors, and to experience gained through use of similar apparatus.

e. Campus Site Modification and Preparation will be done as necessary to accomodate the new monitoring site and instrumentation.

f. The Relocation of Existing Instruments will be performed expeditiously to prevent a loss of data in the present continuous monitoring system. Exposure and operation of the solar radiation and meteorological monitoring instruments will be in accordance with criteria and guidelines published by the WMO(1971) and the IGY (1958).

g. The Instrumentation will be installed and calibrated after it is received and certified.

h. Campus Site Monitoring for the total system is scheduled to begin during the last month of Year 1, but a continuous monitoring system will have been in use for the entire period.

i. The Shenandoah Monitoring System will be used for the entire period after the "Sandia Solar Monitor System" is installed. This basic instrument package will be augmented by additional equipment. Data from the Shenandoah System will be logged on cassette tape. It will then be reformatted and merged with the campus site monitoring data on the CYBER system and put on magnetic tape.

j. Analytical Software will be developed in a standard format which will be used for all research sites. This format was selected at the project directors meeting in Washington, D. C. Data will be taken for analysis

to the CYBER 70/74 computer for transfer to the standard format and storage in this format on magnetic tape, and for transmittal of the raw and summarized data to the National Climatic Center in Asheville.

k. An Instrumentation Calibration by use of a set of special instruments or by techniques specified by the instrument vendor will be performed quarterly to verify instrument accuracy and to establish a permanent record of possible instrument degradation which would affect the acquired data.

l. At the end of each phase of the program, the set of standards would be taken to the Solar Radiation Calibration Facility in Denver, Colorado for Certification of Standard Instruments.

m. The Data Transfer to the National Climatic Center is scheduled to begin on a monthly basis at the end of Year 1 and would continue for the next 48 months. The data will also be stored at Georgia Tech.

Task 2: Solar Energy/Meteorology Training Program

This task involves development and implementation of on-campus, immediate area, and regional training. Existing graduate courses in general meteorology and boundary layer meteorology will be expanded by a new graduate course (open to seniors) in the area of meteorology for solar and wind energy. This course will include training in instrumentation, data acquisition, reduction and analysis. With the formation of an Atmospheric Sciences academic program anticipated to begin in September 1978, this academic curriculum will offer engineers and engineering technologists the opportunity to learn, as a minor or elective course basis, fundamentals of meteorology as it applies to solar energy engineering and technology. It will also allow meteorologists and atmospheric science students in the new program to interact with and learn about the engi-

neering problems and needs related to solar energy technology. This academic program and related short courses for professionals will be made available as appropriate through a unique instructional TV system to become operational at Georgia Tech in September 1978. A "traveling course" to be put on as a short course or a one quarter course at regional colleges will also be implemented. Initially this will be conducted by Georgia Tech personnel. Later, as arrangements are worked out and the local college has personnel trained to proctor or tutor the course, this will be carried via the TV system, either on a video cassette delivery basis, or if the system is developed, via a satellite TV link.

Task 3: Instrumentation and Monitoring Techniques Research

Various research and development aspects related both to the monitoring and the training program, will be carried out under this task. The location of the two monitoring sites - one on-campus within about two miles from the heart of downtown Atlanta, one at the new town Shenandoah site, about 45 miles from Atlanta - will allow evaluation of urban/rural differences, especially related to urban haze and aerosols. The exposure of the instruments adjacent to the Solar Thermal Test Facility and Wind Turbine Test Facility at Georgia Tech will allow evaluation of potential effects on temperature, moisture, and air flow near such facilities. Hence optimum locations will be evaluated for instruments near solar energy facilities, to provide maximum degree of representativeness and minimum influence from the solar energy system on the meteorological measurements. Many models have been proposed in which various meteorological and simply measured radiation parameters (sunshine hours, temperature, cloud cover, solar declination, etc.) can be used to estimate engineering quality insolation (global and direct insolation, global on inclined surfaces, etc.). Some of these methods are those of Fritz (1957), Angstrom (1956), Black et al (1954), Glover and McCulloch (1958), Sabbagh et al (1977), Liu and Jordan (1960),

Whillier (1956) Bennett (1965), Swartman and Ogunladeo (1967), Reddy (1971a, 1971b), Norris (1966), Masson (1966), Atwater (1974), Lumb (1964), L'Vova (1972), Machta (1974), Paltridge (1974), Lin (1973), and Randall et al (1977). Through NOAA (Machta, private communication) a set of linear regression coefficients is being developed for the 26 rehabilitated solar radiation data stations. Using this model, the National Climatic Center will prepare, by November 1977, solar radiation estimates for 200 stations in the U.S. These data will be put on magnetic tape in SOLMET format. The data from the on-campus and off-campus monitoring sites as well as from the 5 Southeastern sites in the new 35 site NOAA network (Riches, 1975) will be used to study regional relationships between simply monitored parameters and solar radiation data for engineering purposes. Results of the contract study resulting from the recent RFP to Perform a Solar Radiation Data Forecast and Interpolation Analysis will also be applied in this study. Emphasis will be on study of the influence of turbidity (high in parts of the Southeast region), and regional geography (which spans coastal, piedmont plains, and mountain areas). During the second and subsequent years up to three low cost portable monitoring units will be designed and built. These units will be used in the training program as instructional systems for the traveling course to regional colleges. Data from these units will also be used in the analysis of methods to relate simple measured parameters to engineering quality insolation data for the region. Other instrument and monitoring techniques for which research and development projects are envisioned will include:

a. an automatic filter changing wheel for the normal incidence pyrheliometer (to automatically switch on a 1/minute or less basis between clear, OG1, RG2, and RG8 filters),
b. circumsolar radiation with the Lawrence Berkley Labs circumsolar telescope, currently on campus and projected to remain here throughout at least a portion of this project, and

c. an automatic wide field of view camera system to provide a film record of cloud cover conditions.

3. ADMINISTRATIVE STATUS

No administrative changes have been made. The project team and organization is now as shown in Fig. 3.1.

4. PROGRESS TO DATE

Task 1: Solar Radiation and Metorological Monitoring Program

a. Completed in prior period. No modifications required.

b. Completed in prior period. No modifications required.

c. Completed in prior period.

d. Completed in prior period.

e. Completed in prior period. Campus site now in full operation.

f. Completed in prior period.

g. During an earlier quarter, the traveling standard CSIRO total radiometer was received and compared to Georgia Tech and Shenendoah total radiometers. Some results were reported at the Davis review meeting. Word on whether large differences (∿10%) in short-wave and long wave calibrations are real is still being awaited from Trinity University.

h. Campus-site monitoring continues. Except for the usual maintenance, all instrumentation functioned properly throughout the quarter.

i. The Shenendoah monitoring system continues in operation. Data reduction and quality control is current.

j. Completed in prior period. Routine daily spot checks continue for the serial output from the on-campus site.

k. See item g, above.

l. A PSP has been sent to NOAA for update calibration check.

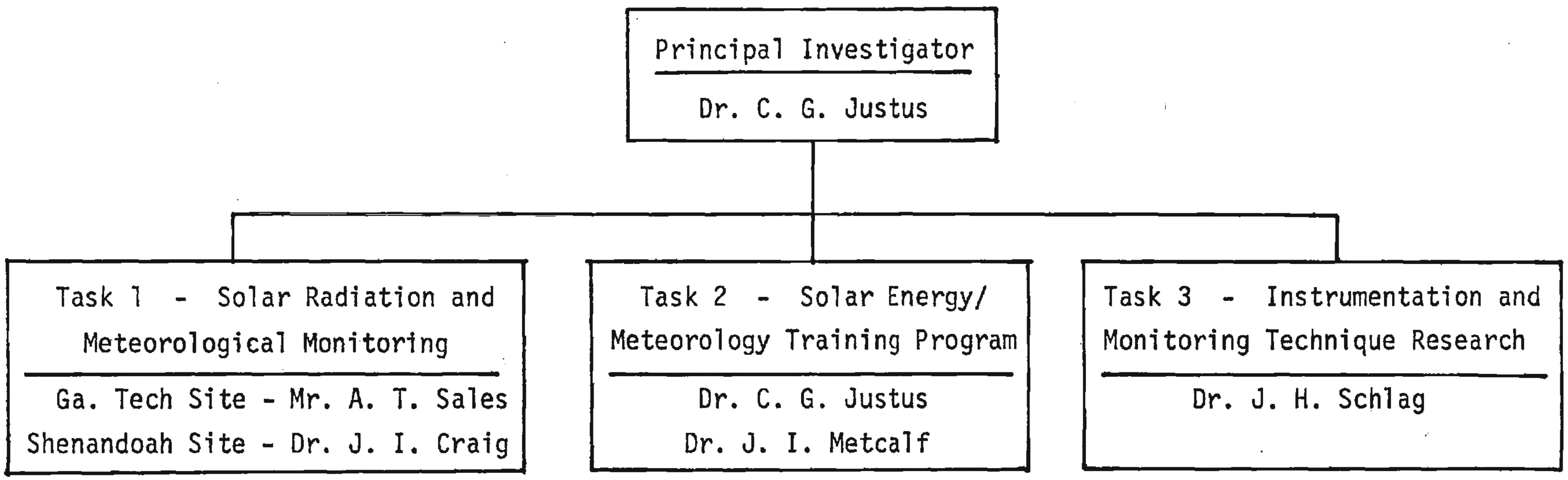


Figure 3.1 - Project Organization Chart

m. Transfer of one year of Shenendoah data to NCC is complete. Transfer of data through January 1981 from the campus site to NCC is complete. Further data will be transferred as it is processed.

Task 2: Solar Energy/Meteorological Training Program

Activities under NSF minority graduate training program "Graduate Research Opportunities in Atmospheric and Terrestrial Sciences" continue.

Task 3: Instrumentation and Monitoring Techniques Research

The all-sky camera system continues to operate well. A visiting faculty member from Jamaica, assisted by a student have completed quantitative analyses of these data, and a special report is in preparation.

The photocell direct beam radiometer continues to undergo field tests. It still appears to compare quite closely with NIP readings (generally $\leq$5% error). The automated sun photometer is in operation, and data has been rendered by Langley plot to determine calibration constants. Comparison studies are underway.

Operation of the Lawrence Berkely labs circumsolar telescope on the Georgia Tech campus is now scheduled to be terminated.

A summer fellowship student has conducted a special study of the NIP-derived sunshine duration compared to Campbell-Stokes and Foster Sunshine switch data. This report, as submitted to Solar Age, is attached as an appendix.

MILESTONES AND BUDGET

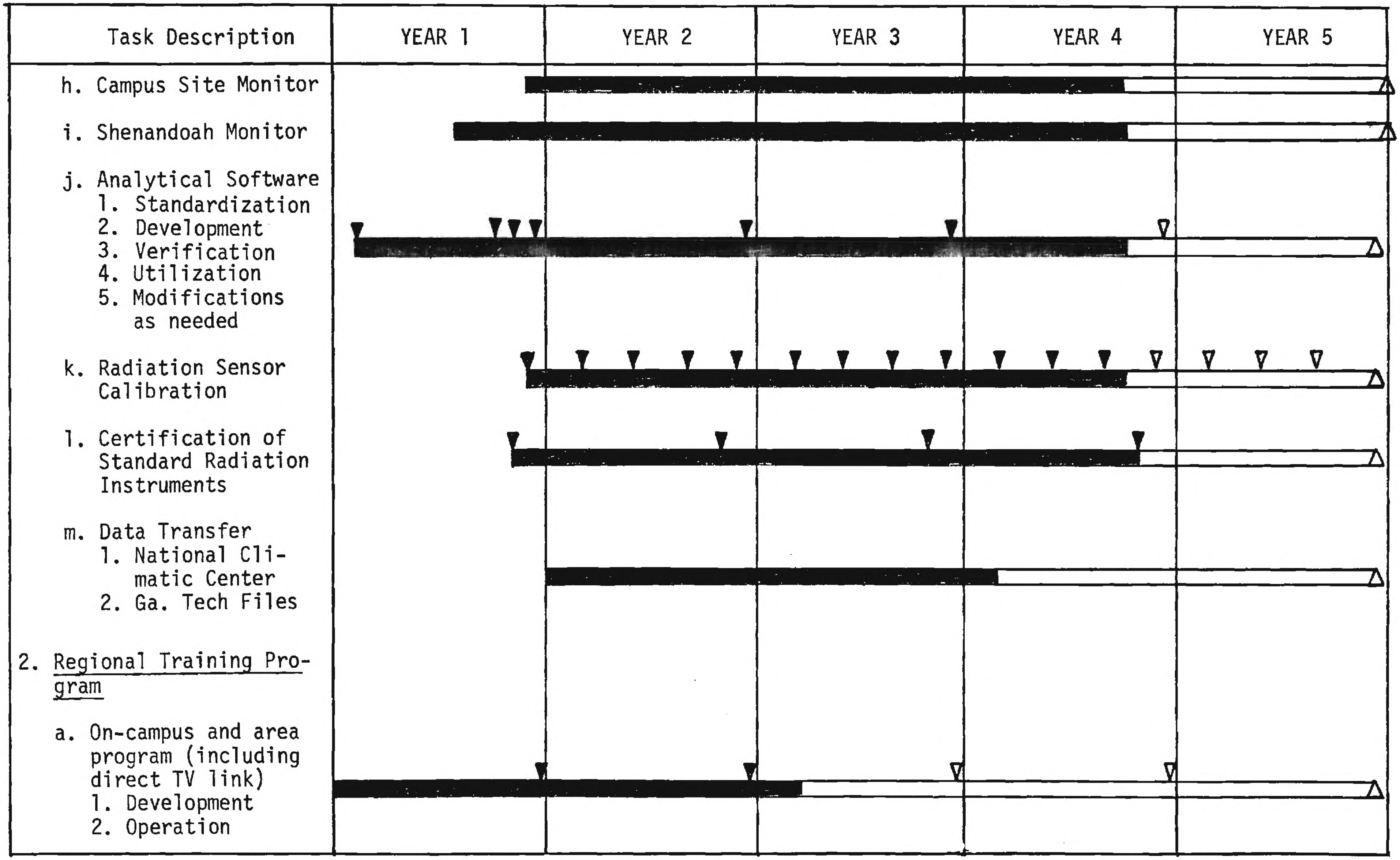
Expenditures in the current project year, through June 1981, total approximately $160,000, which is only 7% over the linear projection project expenditure plan.

A detailed milestone and progress chart is attached.

Milestone Chart

Task Description	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
1. <u>Solar Radiation & Meteorological Monitoring</u>					
a.					
1. Instrument Network Design					
2. Modifications as needed					
b. Selection, order, and delivery of instru.					
c. Instrument check and certification					
d. Auxiliary Hardware 1. Design 2. Mat. Acquisition 3. Fabrication 4. Installation					
e. Campus Site Mod. and preparation					
f. Relocation of Existing Instruments 1. Installation 2. Calibration 3. Temp. Data Acquisition					
g. Instrumentation 1. Installation 2. Electronic and Meteorol. Calibration					

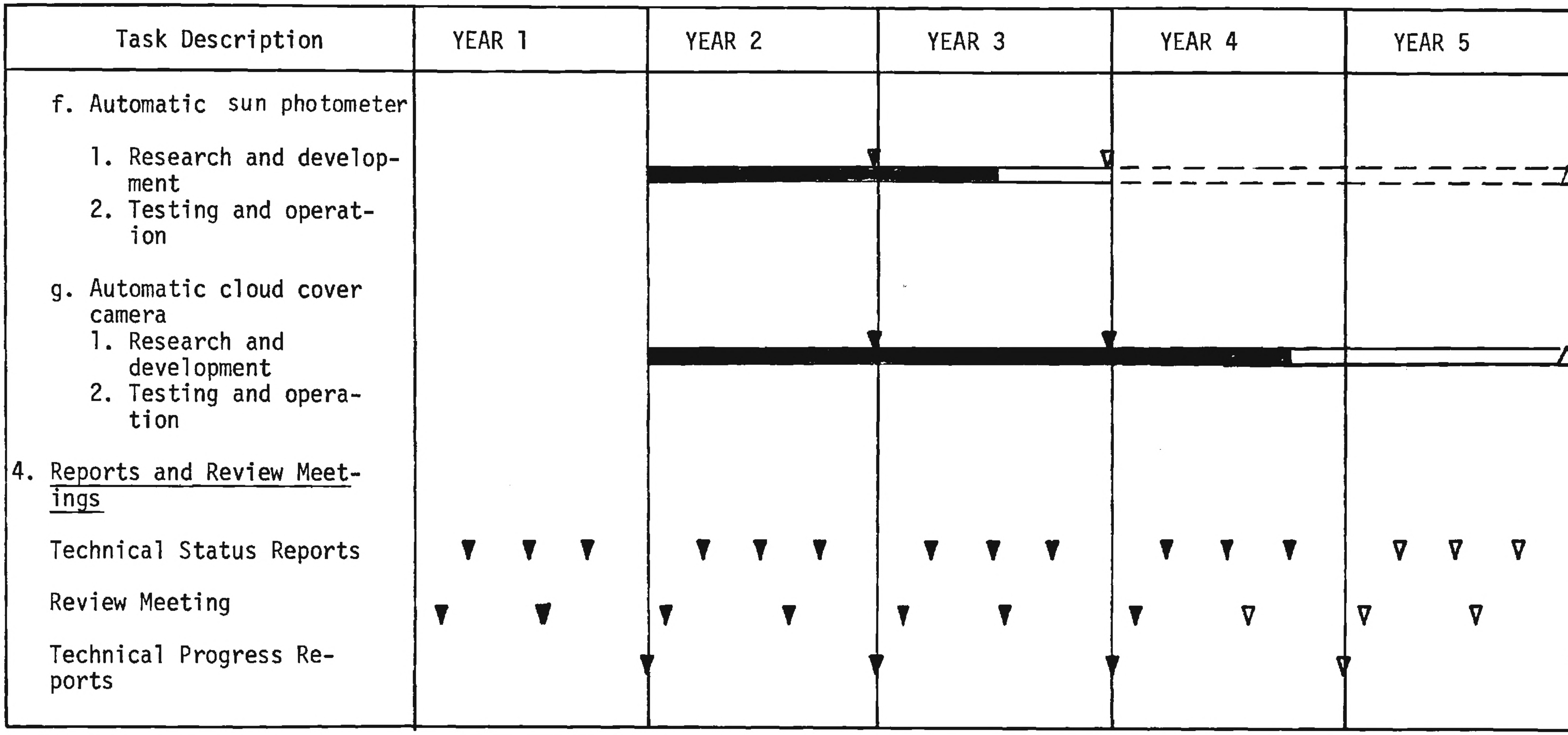
Milestone Chart (Cont'd.)



Milestone Chart (Cont'd)

Task Description	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
b. Southeast Region Training Program 1. Develop regional arrangements 2. In-persion traveling regional courses 3. Regional TV training courses					
3. <u>Instrument and Monitoring Technical Research</u>					
a. Solar Energy Site Influence					
b. Urban/Rural Comparisons					
c. Analysis of Regional Relations					
d. Portable Monitoring Units (PMU) for Training and Regional Study 1. Design (PMU's) 2. Instrument acquisition 3. Construction and testing 4. Cycle of field operation and training courses		Unit 1	Unit 2	Unit 3	
e. On-campus operation of the LBL Circumsolar Telescope					

Milestone Chart (cont'd)



ERRORS IN THE STANDARD FOSTER SUNSHINE DURATION MEASUREMENTS

by

R. B. Benson, M. V. Paris, J. E. Sherry, and C. G. Justus

A comparison of sunshine duration measurements from a Foster sunshine switch at one National Weather Service site to measurements taken with two different instruments in the same city calls into question radiation estimates based on Foster switch data.

Measurements were taken at the Atlanta Airport with a Foster sunshine switch, the standard instrument for measuring sunshine duration at National Weather Service sites. Measurements were taken at the Georgia Institute of Technology with a Campbell-Stokes (CS) recorder, the World Meteorological Organization (WMO) standard sunshine duration instrument, and a normal-incidence pyrheliometer (NIP), configured to record the duration of direct-beam radiation above a fixed threshold of 200 W/m^2. The CS and NIP data agree well, but the Foster sunshine switch gives consistently and significantly different results.

The CS recorder uses a glass ball as a focusing lens. A cardboard chart with special timing marks is inserted into a bowl under the ball. The cardboard chart burns when the direct radiation of the sun is sufficiently intense (above about 210 W/m^2). If the realtive humidity is high or rain has occured, the chart may become damp and more intense radiation is needed to burn it than usual. At any given time the CS threshold for response can vary from as little as 70 W/m^2 to as much as 300 W/m^2 (WMO, 1965).

The Foster sunshine switch makes use of two selenium barrier layer photovoltaic cells. They are mounted so that one cell is blocked from the direct radiation of the sun, but both cells receive diffuse sky radiation.

The diffuse signals are balanced so no electrical signal is generated if a strong beam is absent. In the presence of a strong direct beam, the cell not blocked from the sun triggers a relay and activates a recorder.

The NIP is composed of a multijunction thermopile attached to the base of a brass tube that is chromed on the outside and blackened on the inside. The NIP is airtight, which enables it to remain accurate in wet weather.

The NIP and the CS sunshine recorders used in this study are located on the roof of the Civil Engineering Building of Georgia Tech.

In comparing the data from these three instruments, the NIP was used as the reference instrument since it is considered to be the most accurate. The CS readings vary with humidity, and human judgement has to be taken into consideration when interpreting the burns on the chart.

Comparisons of the CS and the NIP were made with three different data bases: hourly averages, daily averages, and monthly averages. The hourly averages were plotted monthly over the two year period between April 1979 and March 1981. The daily averages were plotted seasonally and yearly over the same two-year period. The monthly averages were plotted over the entire two years. (See Figures 1, 2, and 3). All data were analyzed in terms of percent of possible sunshine for the hour, day or month. Differences in measurements by the three techniques are compared as rms differences in percent possible sunshine.

When the hourly averages were used, there was a 15.5% average rms difference between the CS and the NIP.(See Table 1). The rms difference for the daily averages dropped by almost one half to 8.5% average rms. The monthly average rms difference of 4.1% expresses about another 50% drop in rms from the daily average rms difference (See Table 2).

For the comparison of the Foster and the NIP the only available data were daily averages of percent sunshine and monthly averages of percent sunshine. These averages were plotted in the same fashion as the CS-versus-NIP plots for the same data bases (See Figures 4 and 5).

When the daily averages were used as data, there was an 18.2% average rms difference between the Foster and NIP. The monthly average plots revealed a 12.4% rms between the two instruments (See Table 2).

Because of random errors, there should be a significant drop in rms difference from a shorter time-span data base to a longer time-span data base. The CS-versus-NIP comparison reveals this drop by decreasing by approximately a factor of 2 from one data base to another. The Foster-versus-NIP plots do not reveal the same type of significant drop in rms from one data base to another. This behavior is indicative of a non-random bias error between these two instruments. For the data available, the Foster sunshine switch at the Atlanta Airport appears to read consistently about 12% higher, on average, than the CS and the NIP. The consistency between the NIP and CS readings would support the argument that it is the Foster readings which are high. This is also supported by comparison with sunshine estimates from sunrise-to-sunset average cloud-cover readings at the Atlanta Airport. (See Table 3).

In addition to consistent bias error, the cloud cover and Foster sunshine data in Table 3 show revealing seasonal variation in their deviations from the NIP sunshine values. No such seasonal variation exists in the CS-NIP differences, again tending to confirm the accuracy of these instruments. The observed seasonal variation in the cloud-inferred sunshine estimates is easily explained: Not all clouds are completely opaque, hence there is a small negative bias. In the summertime, clouds are predominantly cumulus type and opaque, with wintertime clouds being more frequently composed of partially transparent cloud types. The sunshine estimates based on average cloud, not average opaque cloud, would therefore tend to be most accurate in the summer and least accurate in the winter, with a consistent negative bias, as observed.

The seasonal variation of the Foster sunshine deviations from the NIP percent sunshine, shown in Table 3, indicates a possible source of error. If a simple, seasonally-invariant threshold error is assumed for the Foster switch, its sunshine readings would be expected to be least accurate in the shorter winter months and most accurate in the longer summer months. In fact, the observed errors in the Foster data have just the opposite pattern, with an average of about +9% in the winter months and about +17% in the summer months. In the time of sunshine duration, these represent about 1 hour extra indicated sunshine in winter and about 2 hours extra indicated sunshine in summer. The observed Foster errors are consistene with readings relative to a higher threshold in winter, at low sun angles, and to a lower threshold in summer, at high sun angles, with the threshold being lower than 200 W/m^2 (the NIP threshold used) for all times of year. This behavior suggests a "cosine-correction" type of error in the Foster measurements.

From discussions with meteorologists at several airport sites at which Foster sunshine switches are used, this level of inaccuracy is not surprising, and although the Atlanta instrument gave consistently high readings, these meteorologists would not be surprised to find consistently low Foster readings at other sites. The errors are typically due to lack of quality control in calibrating during regular operation.

Lunde (1981) recently expressed concern over the use of "ersatz) or "blue book" reference data for solar radiation (Cinquemani et al, 1978), which is mostly estimated from percent sunshine regressions. The results presented here indicate that one of the main sources of error in these data, which are widely used for solar energy calculation, may be in the basic sunshine duration measurements themselves. If 12% bias errors in the Foster sunshine measurements are typical, then errors of at least this magnitude would be typical in solar energy performance estimates based on these erroneous data.

References:

1) Cinquemani, V., J.R. Owenby, Jr., and R.G. Baldwin (1978): "Input Data for Solar Systems", EDIS, National Climatic Center, Interagency Agreement E (49-26)-104.

2) Lunde, Peter J. (1981): "Revised Radiation Data Compound Old Errors", Solar Age, 6 (7), 47-48.

3) World Meteorological Organization (1965): "Measurements of Radiation of Sunshine. Guide to Meteorological Instrument of Observing Practices", 2nd ed., WMO 8, TP3.

TABLE 1

RMS VALUES OF CAMPBELL-STOKES VERSUS NIP

USING HOURLY AVERAGES

MONTH	RMS FOR CS % SUNSHINE VS. NIP % SUNSHINE*
APR 79	11.892
MAY 79	18.308
JUN 79	15.909
JUL 79	19.262
AUG 79	17.414
SEP 79	15.962
OCT 79	14.039
NOV 79	11.264
DEC 79	9.894
JAN 80	15.449
FEB 80	8.818
MAR 80	13.809
APR 80	17.884
MAY 80	19.367
JUN 80	21.279
JUL 80	24.356
AUG 80	22.574
SEP 80	17.805
OCT 80	14.576
NOV 80	8.735
DEC 80	12.368
JAN 81	10.550
FEB 81	12.767
MAR 81	17.346
	(15.48)

* To avoid large errors which occur at low sun angles, only hours with solar elevations above 15° were considered.

TABLE 2

COMPARISON OF SEASONAL AND YEARLY DAILY AVERAGES AND TOTAL AVERAGE OF THE RMS MONTHLY AVERAGES OF SUNSHINE DURATION

DATA	TIME SPAN	RMS FOR CAMPBELL-STOKES % SUNSHINE VS. NIP % SUNSHINE	RMS FOR FOSTER % SUNSHINE VS. NIP % SUNSHINE
DAILY AVG.	APR 79-JUN 79	9.031	18.191
DAILY AVG.	JUL 79-SEP 79	7.848	21.554
DAILY AVG.	OCT 79-DEC 79	7.933	12.369
DAILY AVG.	JAN 80-MAR 80	10.209	14.691
DAILY AVG.	APR 80-JUN 80	7.676	20.131
DAILY AVG.	JUL 80-SEP 80	8.800	23.915
DAILY AVG.	OCT 80-DEC 80	8.067	15.415
DAILY AVG.	JAN 81-MAR 81	8.506	16.526
DAILY AVG.	APR 79-MAR 80	8.791	17.062
DAILY AVG.	APR 80-MAR 81	8.277	19.314
MONTHLY AVG.	APR 79-MAR 81	4.052	12.383

TABLE 3

COMPARISON OF MONTHLY AVERAGES OF AVAILABLE SUNSHINE MEASURED BY THREE METHODS

	Atlanta, Georgia Tech Site			Atlanta Airport Site			
	Observed % Sunshine (NIP)	Observed % Sunshine (Campbell-Stokes)	Deviation	Observed % Sunshine (Foster)	Deviation	Sunshine Inferred from Cloud Cover	Deviation
APR 79	49	49	0	57	+8	37	-12
MAY 79	40	46	+6	53	+13	32	-8
JUN 79	49	48	-1	66	+17	39	-10
JUL 79	35	36	+1	51	+16	23	-12
AUG 79	51	51	0	68	+17	47	-4
SEP 79	33	30	-3	42	+9	27	-6
OCT 79	68	62	-6	74	+6	59	-9
NOV 79	58	57	-1	62	+4	49	-9
DEC 79	54	50	-4	59	+5	41	-13
JAN 80	29	29	-0	35	+6	19	-16
FEB 80	58	51	-7	66	+8	43	-15
MAR 80	44	38	-6	52	+8	25	-19
APR 80	53	54	+1	64	+11	45	-8
MAY 80	44	40	-4	60	+16	35	-9
JUN 80	53	47	-6	68	+15	47	-6
JUL 80	63	57	-6	83	+20	59	-4
AUG 80	55	50	-5	76	+21	53	-2
SEP 80	49	47	-2	66	+17	41	-8
OCT 80	58	56	-2	70	+12	51	-7
NOV 80	54	50	-4	60	+6	46	-8
DEC 80	56	57	+1	65	+9	48	-8
JAN 81	68	63	-5	78	+10	58	-10
FEB 81	51	48	-3	62	+11	32	-19
MAR 81	64	58	-6	74	+10	46	-18
	52	49 (-3)	4 RMS	63 (+11)	12 RMS	42 (-10)	11 RMS

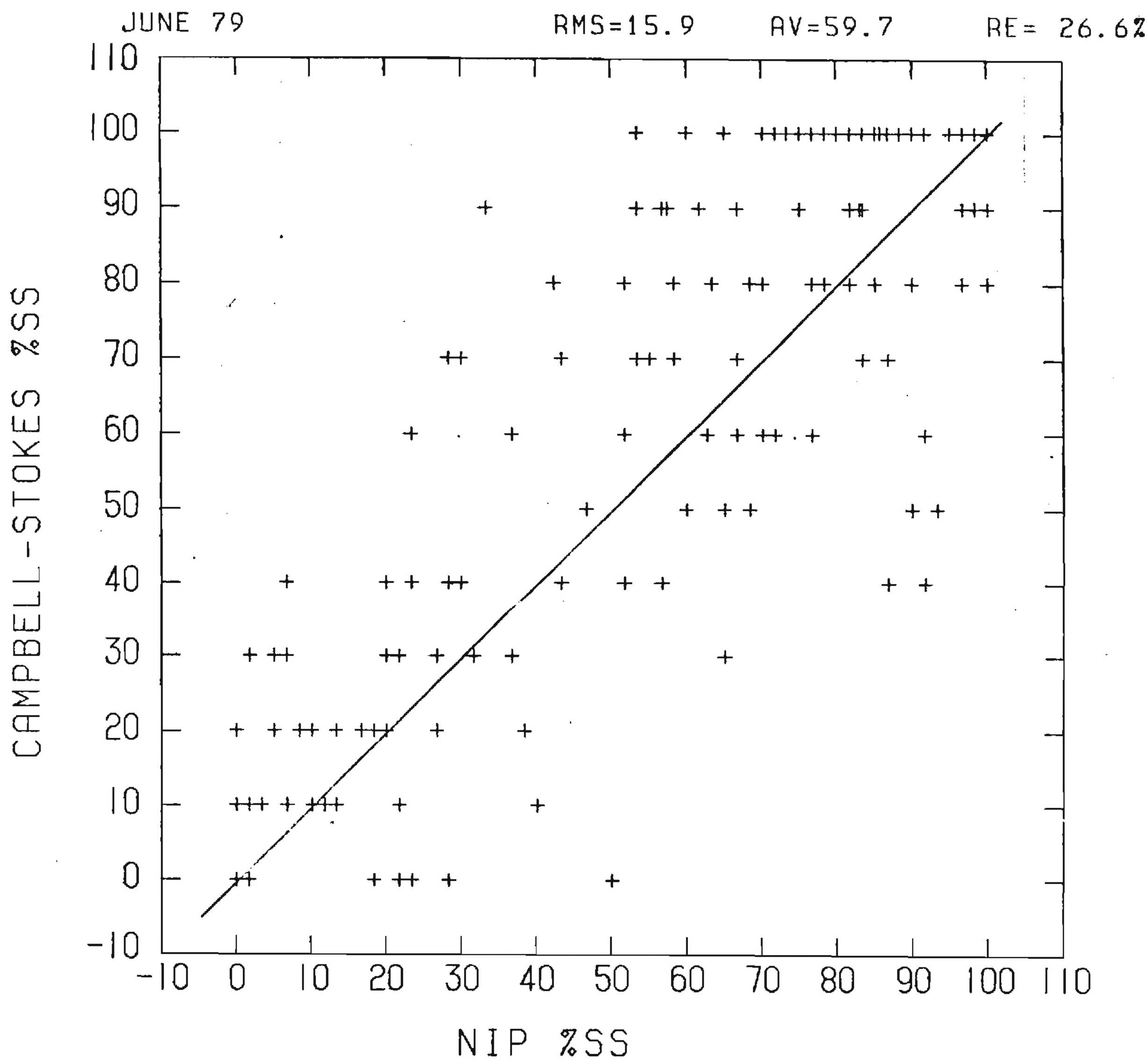


Figure 1: Hourly average plot of CS vs. NIP % Sunshine for June, 1979, shows a 15.9% rms, which is typical of the hourly average data over a month.

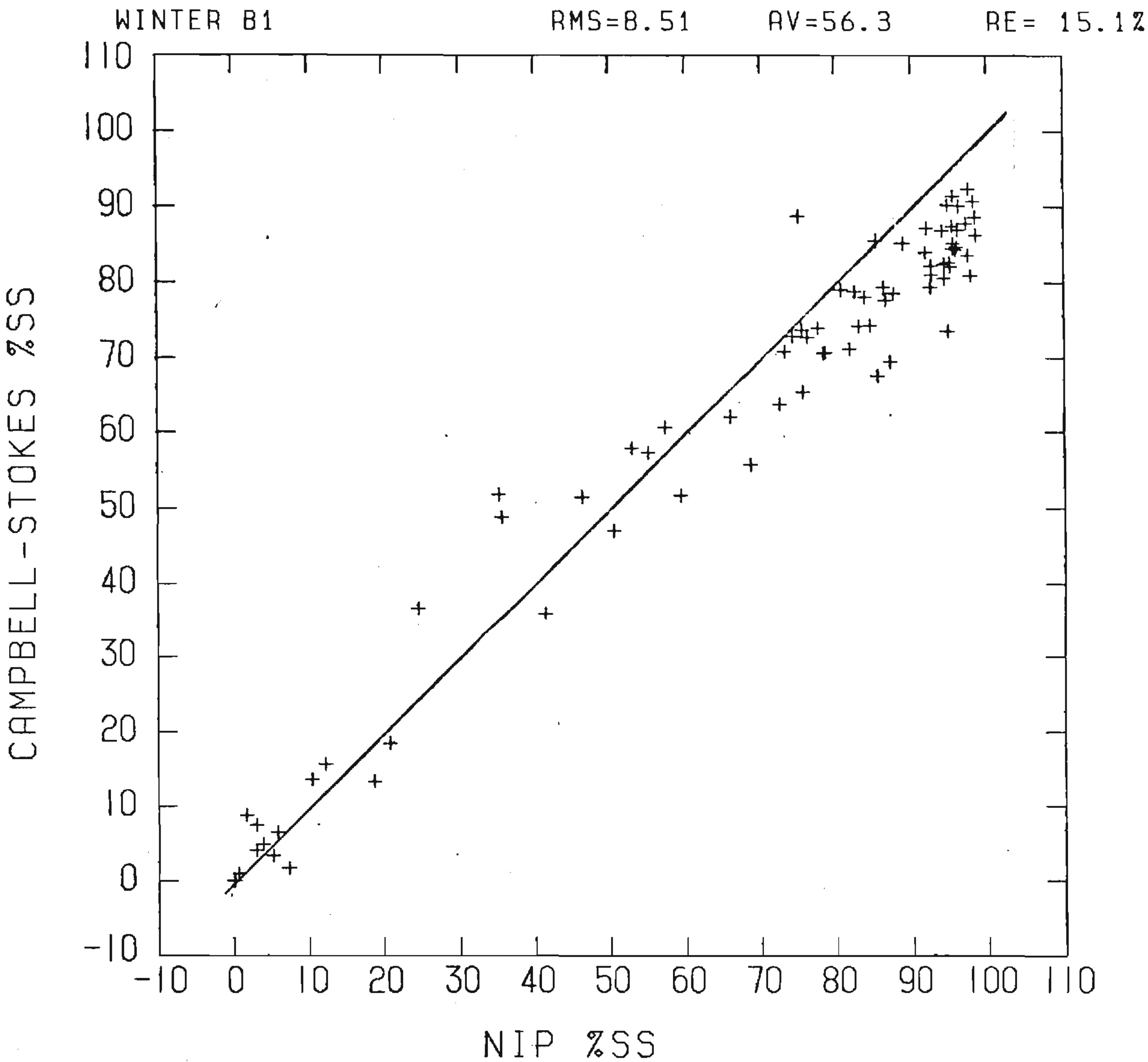


Figure 2: Daily average plot of CS vs. NIP % sunshine for winter, 1981, shows almost a 50% drop in rms from hourly average to 8.5% rms, which is typical of the daily average data over a season.

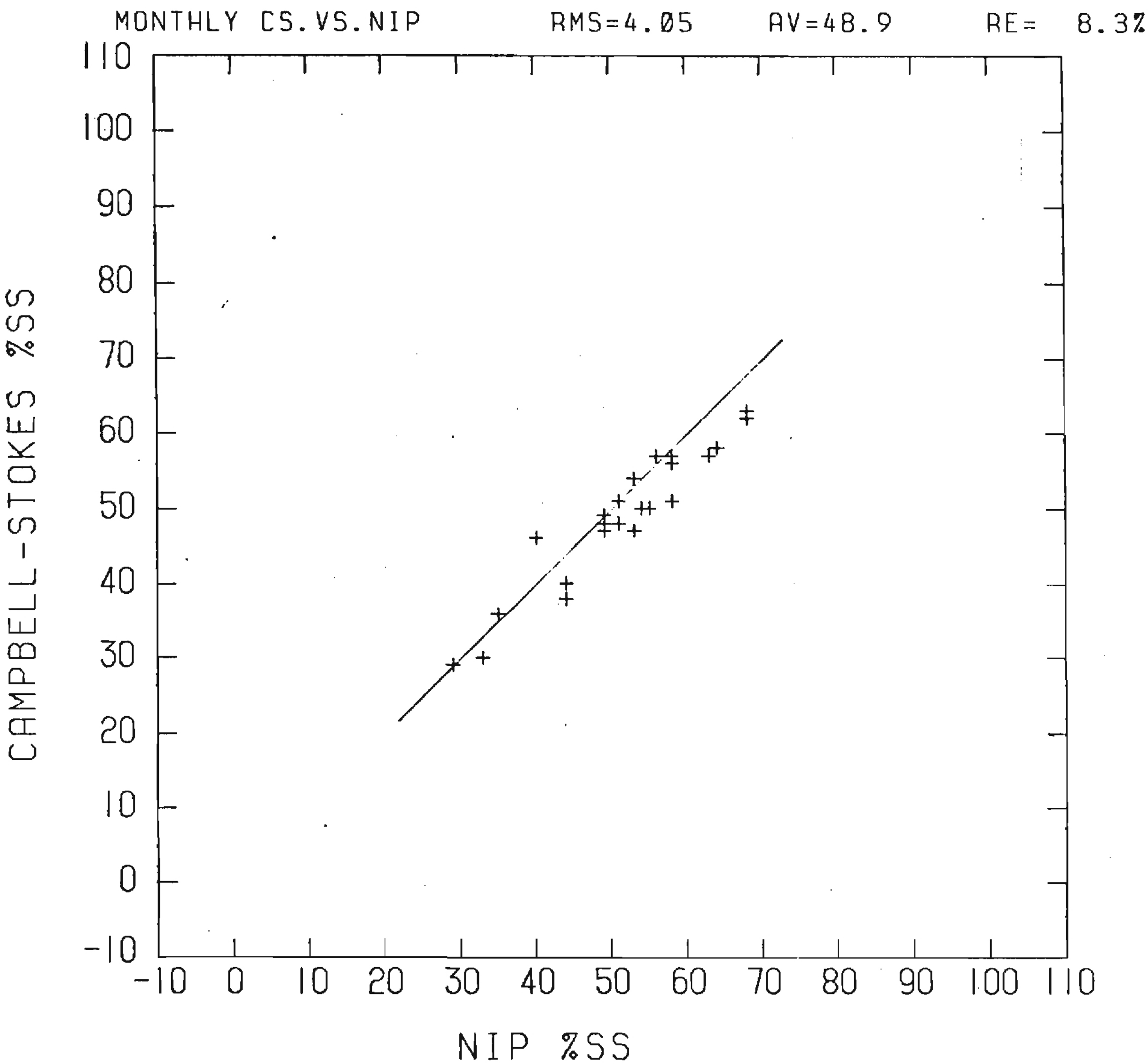


Figure 3: Monthly average plot of CS vs. NIP % sunshine for the two years, April 1979 to March 1981, shows a reduction in rms by a factor of about two from the daily averages to 4.1% rms.

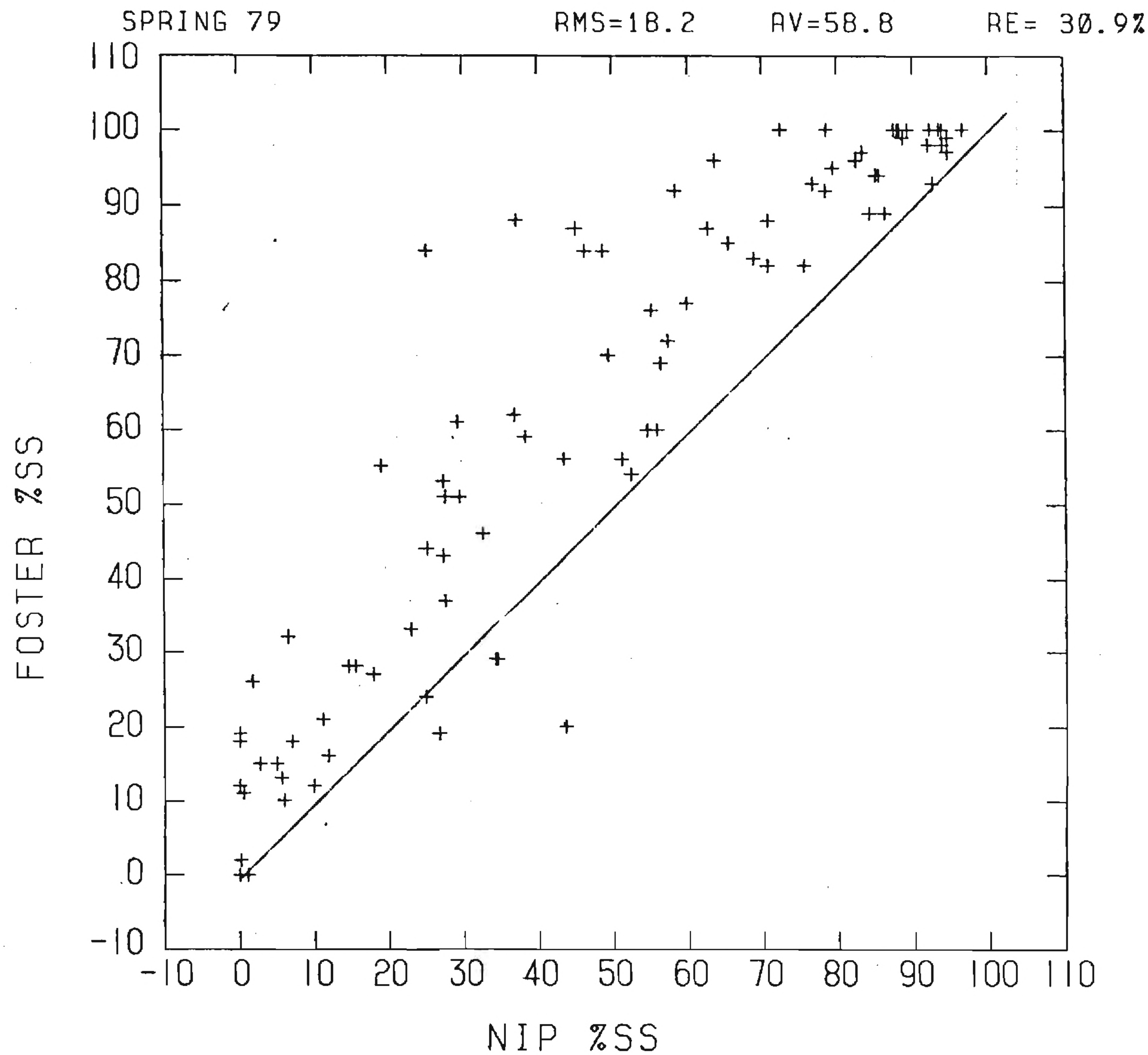


Figure 4: Daily average plot of Foster vs. NIP sunshine for Spring, 1979, shows an 18.2% rms which is typical of the daily average data over a month. Bias error in the Foster data is evident from comparison to the one-to-one regression line.

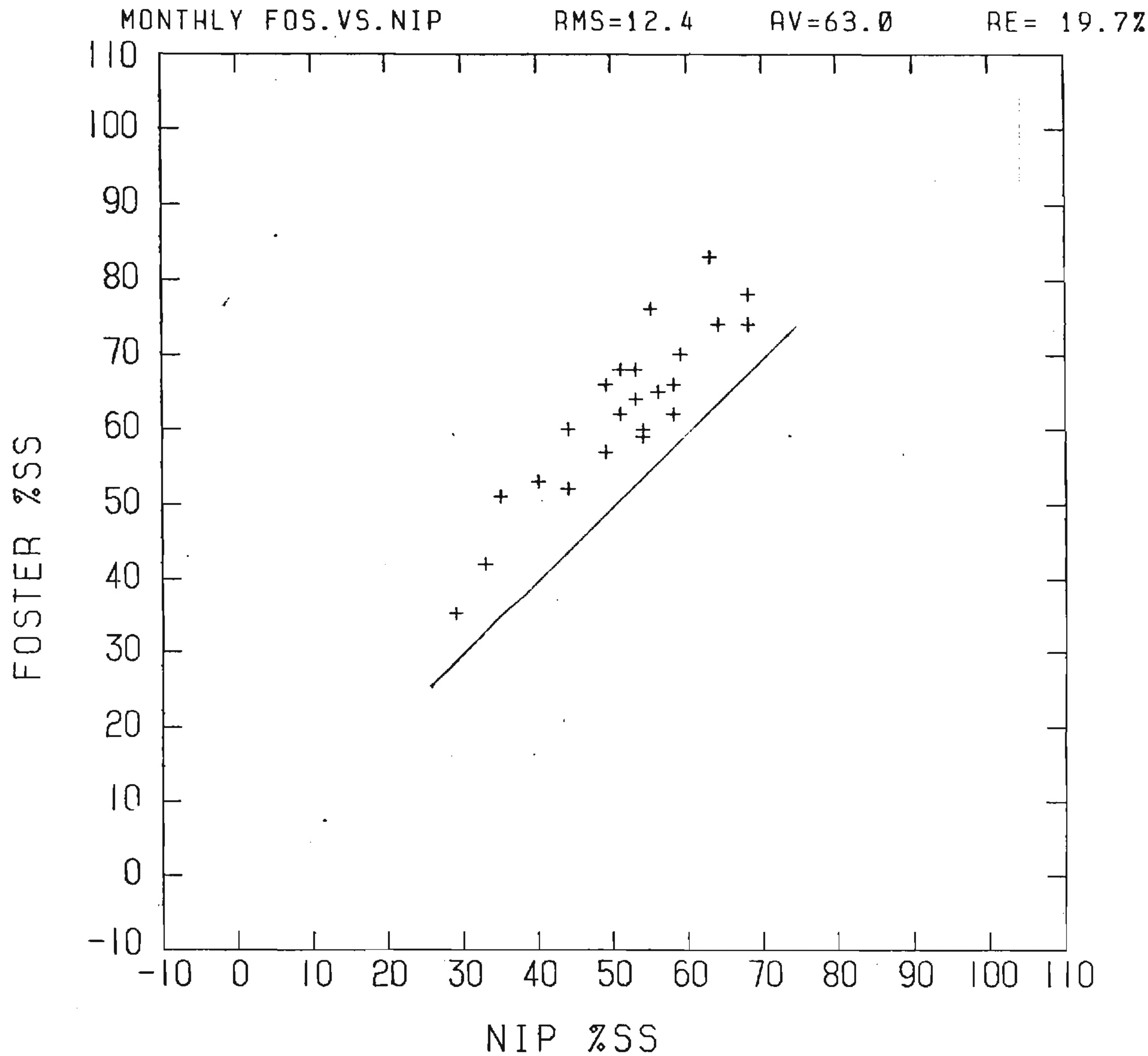


Figure 5: Monthly average plot of Foster vs. NIP % sunshine for the two years, April 1979 to March 1981, shows a 12.4% rms deviation between Foster and NIP data. Bias error in the Foster data is evident from the comparison to the one-to-one regression line.

E-16-C03

SOLAR ENERGY METEOROLOGICAL RESEARCH AND TRAINING SITE PROGRAM - REGION III (ANNUAL REPORT OCTOBER 1980 - SEPTEMBER 1981)

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BACKGROUND

Eight regional university Solar Energy Meteorological Research and Training Site (SEMRATS) Program Sites have been established around the United States. The Georgia Institute of Technology is the SEMRATS center for the Southeastern region, including Florida, Georgia, Alabama, Mississippi, Tennessee, South Carolina, North Carolina, Virginia, Kentucky West Virginia, Maryland, the District of Columbia, and Delaware. Permanent monitoring sites on the Georgia Tech campus and at Shenendoah, about 60 km (40 miles) southwest of the campus site, continuously monitor and record global, direct, diffuse, global tilted, UV, IR, and other spectral radiation parameters. A careful program of instruments and electronic calibration add quality control insures the accuracy of these recorded data. Programs of training for students at Georgia Tech and for professionals in the field are also carried out in the area of solar energy resource assessment.

Significant earlier progress has been reported in the 1977-78 annual report [1] and the 1979-80 annual report [3] which give a complete site and instrumentation description for the Georgia Tech and Shenendoah sites, as well as a description of the data processing and quality control procedures used. An atlas of the solar radiation resources for the southeast region was prepared as the 1978-79 annual report [2].

DESCRIPTION OF DATA

The measurements being taken and instruments used are summarized in Table 1 and earlier reports [1-3]. Data are logged by an Acurex data logger and Cypher tape deck, then processed on a Data General Eclipse S-130 computer system. A combination of automatic and manual editing is used in the quality control of the data, with about 3-5 person days per month being required in the manual editing process. At the Shenendoah site a similar but less complete set of instrumentation is used. Data at that site are logged on a EG&G data logger and tape cassette recorder, with a similar quality control procedure.

Hourly averages from both the Georgia Tech campus site and the Shenendoah site are available in Research Cooperator format through the National Climatic Center in Asheville, NC, or through the Solar Energy Research Institute (SERI) in Golden, Colorado. The one-minute data from the Georgia Tech site for July 1980 through June 1981 are archived at SERI. Tables of hourly values and daily and monthly totals for the periods of April 1979-March 1980 and April 1980-March 1981 for selected radiation parameters are also given in Appendix A of earlier reports [3], [4]. Monthly averages of meteorological and radiation

TABLE 1.

ATLANTA, GEORGIA TECH SITE
(C.E. BUILDING ROOF ON GA. TECH CAMPUS)
RESEARCH COOPERATOR DATA DESCRIPTION

Latitude = 33° 46' 37" N
Longitude = 84° 23' 54" W
Time Zone = Eastern (5)

Element Code	Elevation MSL, m	Elevation AGL, m	Orientation Azimuth	Orientation Tilt	Spectral Band μ Lower	Spectral Band μ Upper	Description	Units
1000	326.8	34.8	0	0	0.29	2.80	Global Horizontal, Eppley PSP	kJ/m^2
1001	326.8	34.8	0	0	0.29	2.80	Global Horizontal, Spectrolab SR 75	kJ/m^2
1002(1)	326.8	34.8	0	0	0.38	1.20	Global Horizontal, LiCor Lambda	kJ/m^2
1003(1)	326.8	34.8	0	0	0.38	1.20	Global Horizontal, Dodge Products Solar Cell	kJ/m^2
1460	326.8	34.8	180	34	0.29	2.80	Global Latitude Tilted, PSP w/artificial horizon	kJ/m^2
1461(2)	326.8	34.8	180	34	0.29	2.80	Global Latitude Tilted, Lambda w/artificial horizon	kJ/m^2
2010	326.8	34.8	-	-	0.29	2.80	Direct Normal, Eppley NIP	kJ/m^2
2011(2)	326.8	34.8	-	-	0.29	2.80	Direct Normal, Eppley NIP (redundant)	kJ/m^2
2012(2)	326.8	34.8	-	-	0.38	1.20	Direct Normal, LiCor Lambda w/colimator	kJ/m^2
3000(3)	326.8	34.8	0	0	0.29	2.80	Diffuse, PSP and tracking disk	kJ/m^2
3001(3)	326.8	34.8	0	0	0.29	2.80	Diffuse, PSP and tracking disk	kJ/m^2
5000	326.8	34.8	0	0	0.30	0.39	UV, Eppley TUVR	kJ/m^2
6000(4)	326.8	34.8	0	0	2.80	60.0	IR from Total Incoming (Funk) minus Global (PSP)	kJ/m^2
6001(4)	326.8	34.8	0	0	3.5	50.0	IR from Eppley PIR	kJ/m^2
7000	326.8	34.8	0	0	0.63	2.80	Global Spectral, PSP and RG2 filter	kJ/m^2
7010	326.8	34.8	0	0	0.63	2.80	Direct Normal Spectral, NIP and RG2 filter	kJ/m^2
9000(5)	326.8	34.8	-	-	-	-	% Possible Sunshine, Campbell Stokes	%
9001(5)	326.8	34.8	-	-	-	-	% Possible Sunshine, NIP w/200 W/m^2 threshold	%
9150(6)	326.8	34.8	-	-	-	-	Rainfall	mm
9200	332.9	40.9	-	-	-	-	Wind Direction, lower level	deg
9201	343.3	51.3	-	-	-	-	Wind Direction, upper level	deg
9210	332.9	40.9	-	-	-	-	Wind Speed, lower level	m/s
9211	343.3	51.3	-	-	-	-	Wind Speed, upper level	m/s
9300	329.8	37.8	-	-	-	-	Dry Bulb Temperature, lower level	°C
9301	343.0	51.0	-	-	-	-	Dry Bulb Temperature, upper level	°C
9320	329.8	37.8	-	-	-	-	Dew Point Temperature, lower level	°C
9321	343.0	51.0	-	-	-	-	Dew Point Temperature, upper level	°C
9400	326.8	34.8	-	-	-	-	Station Pressure	kPa

(1)Not available after 10/26/79; (2)Available after 2/1/80; (3)Available after 1/10/80; (4)Available after 4/14/80;
(5)Available only in hourly RCF; (6)Minute rainfall is cumulative from beginning of hour.

TABLE 2

1979 ATLANTA, GEORGIA TECH AND ATLANTA AIRPORT (NWS) DATA

Lat 33.75 N Lon 84.40 W

Atlanta, Georgia Tech	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Temperature (Deg. C)	-	-	-	16.7	20.6	23.4	25.3	25.8	21.5	16.6	12.9	8.5
Heating Degree (C) Days	-	-	-	57	12	0	0	0	5	71	160	304
Cooling Degree (C) Days	-	-	-	14	80	152	216	232	101	18	3	0
Dewpoint Temp. (Deg. C)	-	-	-	5.9	11.0	13.0	17.2	17.4	14.6	8.0	4.9	1.4
Avg. Wind Speed (m/s)	-	-	-	3.8	3.2	3.0	3.1	2.4	3.5	3.3	3.3	3.7
Resultant Wind Direction (Deg)	-	-	-	356	164	20	245	310	51	236	286	307
Precipitation (cm)	-	-	-	25.54	7.56	1.89	8.56	12.27	13.45	6.78	13.57	1.83
Direct Normal (MJ/m2.day)	-	-	-	16.1	12.7	14.8	10.6	13.5	8.1	20.4	15.7	13.8
Direct RG630 (MJ/m2.day)	-	-	-	10.1	8.0	8.9	7.3	9.8	5.8	14.0	10.9	9.4
Global Horizontal (MJ/m2.day)	-	-	-	18.0	18.3	21.2	17.4	19.1	12.3	14.7	9.9	8.2
Global RG630 (MJ/m2.day)	-	-	-	10.5	10.9	12.7	9.9	11.1	7.0	8.7	5.8	4.9
Diffuse Horizontal (MJ/m2.day)	-	-	-	6.1	9.2	11.0	9.9	10.2	7.3	4.0	3.2	2.9
Lat. Tilted Global (MJ/m2.day)	-	-	-	18.1	16.7	18.5	15.5	18.5	12.9	19.7	15.1	13.5
Infrared [3-60 u] (MJ/m2.day)	-	-	-	-	-	-	-	-	-	-	27.9	26.5
UV [0.30-0.39 u] (MJ/m2.day)	-	-	-	0.94	0.97	1.11	0.92	0.94	0.65	0.71	0.48	0.41
Available Sunshine (%)	-	-	-	51	40	48	36	52	32	67	55	50
ETR Horizontal (MJ/m2.day)	-	-	-	36.2	40.0	41.4	40.7	37.7	32.6	26.1	20.5	17.7

Lat 33.65 N Lon 84.42 W

Atlanta Airport (NWS)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Temperature (Deg. C)	2.9	5.4	13.4	17.1	21.2	24.3	26.0	26.7	22.6	16.9	12.4	8.2
Heating Degree (C) Days	474	359	155	54	9	0	0	0	3	68	178	311
Cooling Degree (C) Days	0	0	7	18	101	182	242	264	135	27	3	0
Dewpoint Temp. (Deg. C)	-3.3	-0.6	4.4	8.3	14.4	16.1	20.6	20.0	18.3	10.6	6.1	0.0
Avg. Wind Speed (m/s)	5.1	4.6	4.5	4.5	3.8	3.9	4.1	3.6	4.9	4.1	4.4	4.7
Resultant Wind Direction (Deg)	320	320	240	310	220	10	170	340	70	250	280	320
Precipitation (cm)	12.78	14.50	8.10	30.12	6.17	3.71	9.19	18.49	15.44	5.51	13.18	1.75
Available Sunshine (%)	44	44	62	57	53	66	51	68	42	74	62	59
Sky Cover [sr-ss] (10ths)	7.7	7.6	6.5	6.3	6.8	6.1	7.7	5.3	7.3	4.1	5.1	5.9

parameters are tabulated for this period and compared with results for the nearby Atlanta Airport National Weather Service station in Tables 2-4.

Research results presented here include: 1) measurements of the solar spectral irradiance made at Golden, Colorado, using the SERI spectroradiometer, 2) analysis of turbidity measurements using the Volz photometer and a Georgia Tech designed 500 nm turbidity sensor, 3) effects of turbidity and precipitable water on the direct beam, the spectral ratio of RG630-to-full-spectrum direct beam, and the diffuse-to-direct beam ratio, 4) comparisons of diffuse radiation measured with a tracking disc system and a shadow-band system, 5) an analysis of IR errors due to non-linear short-wave response of the Funk type (CSIRO) total radiometer.

TABLE 3

Lat 33.75 N Lon 84.40 W Atlanta, Georgia Tech	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	1980 ATLANTA, GEORGIA TECH AND ATLANTA AIRPORT (NWS) DATA											
Temperature (Deg. C)	7.6	5.8	11.1	16.4	21.2	25.0	28.4	27.3	24.5	15.2	11.6	7.3
Heating Degree (C) Days	332	364	225	76	4	0	0	0	12	107	202	342
Cooling Degree (C) Days	0	1	2	19	95	200	312	278	206	14	0	0
Dewpoint Temp. (Deg. C)	1.9	-3.8	2.9	7.2	14.2	17.8	20.9	19.7	17.6	7.9	3.0	-2.4
Avg. Wind Speed (m/s)	3.7	3.8	4.8	4.2	3.2	3.1	2.8	2.4	2.6	3.1	3.5	3.4
Resultant Wind Direction (Deg)	321	299	343	247	227	252	244	212	56	314	313	289
Precipitation (cm)	18.12	8.89	31.83	5.71	17.58	6.66	2.74	0.86	12.55	4.45	4.17	2.01
Direct Normal (MJ/m2.day)	7.4	16.2	13.2	17.3	12.2	16.3	17.7	13.8	13.0	18.0	15.3	14.4
Direct RG630 (MJ/m2.day)	4.9	11.0	8.8	11.7	8.6	11.4	12.4	10.2	9.3	11.8	10.1	10.2
Global Horizontal (MJ/m2.day)	6.1	12.3	13.1	18.9	18.8	21.9	23.3	19.3	15.4	14.0	10.0	8.9
Global RG630 (MJ/m2.day)	3.8	7.4	8.2	10.9	10.7	12.7	13.7	11.5	9.2	8.6	6.4	5.7
Diffuse Horizontal (MJ/m2.day)	3.2	4.1	5.3	7.4	10.1	9.9	10.5	9.5	7.5	4.1	3.0	2.8
Lat. Tilted Global (MJ/m2.day)	8.8	16.9	15.2	18.9	17.0	18.9	20.6	18.8	16.8	18.5	15.7	14.6
Infrared [3-60 u] (MJ/m2.day)	27.8	25.9	-	-	-	33.8	35.8	35.7	35.4	29.8	28.7	27.8
UV [0.30-0.39 u] (MJ/m2.day)	0.33	0.59	0.65	0.89	0.88	1.06	1.13	0.96	0.80	0.71	0.49	0.42
Available Sunshine (%)	26	54	41	53	44	50	61	65	49	60	56	55
ETR Horizontal (MJ/m2.day)	19.0	23.9	30.5	36.3	40.0	41.4	40.6	37.5	32.4	25.9	20.3	17.6

Lat 33.65 N Lon 84.42 W Atlanta Airport (NWS)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Temperature (Deg. C)	7.2	5.5	11.2	17.0	22.2	26.2	29.5	28.8	26.1	16.4	11.1	7.2
Heating Degree (C) Days	342	371	222	63	2	0	0	0	10	86	217	343
Cooling Degree (C) Days	0	2	2	27	126	238	351	327	244	28	0	0
Dewpoint Temp. (Deg. C)	2.8	-2.8	3.9	8.3	15.0	18.8	21.7	21.0	20.0	10.6	3.3	-1.7
Avg. Wind Speed (m/s)	4.8	4.7	5.6	4.8	4.0	4.0	3.6	3.5	3.6	4.1	4.6	4.3
Resultant Wind Direction (Deg)	340	310	350	260	250	270	270	250	70	320	340	310
Precipitation (cm)	14.45	6.83	29.62	4.78	21.26	11.40	1.93	4.04	12.12	4.09	5.44	3.28
Available Sunshine (%)	35	66	52	64	60	68	83	76	66	70	60	65
Sky Cover [sr-ss] (10ths)	8.1	5.7	7.5	5.5	6.5	5.3	4.1	4.7	5.9	4.9	5.4	5.2

SUMMARY OF RESULTS

Solar Spectral Irradiance Measurements

During the summer of 1981, measurements of the solar spectral irradiance at Golden, Colorado were made using the Solar Energy Research Institute (SERI) spectroradiometer. The radiometer measures the spectrum of solar energy between 0.3 and 2.5 microns wavelength in less than 2.5 minutes, with $\sim$0.01 μm resolution in the infrared. A minicomputer controls the instrument and provides data reduction and analysis. Three modes of measurement are available: total or global, direct normal and diffuse.

The SERI solar spectroradiometer (SSR) is a complex instrument which

TABLE 4

Lat 33.75 N Lon 84.40 W — 1981 ATLANTA, GEORGIA TECH AND ATLANTA AIRPORT (NWS) DATA

Atlanta, Georgia Tech	JAN	FEB	MAR	APR	MAY	JUN*	JUL	AUG	SEP	OCT	NOV	DEC
Temperature (Deg. C)	4.4	8.5	11.3	19.8	19.5	25.7	27.1	24.6				
Heating Degree (C) Days	432	274	221	20	30	0	0	0				
Cooling Degree (C) Days	0	0	4	65	66	221	272	194				
Dewpoint Temp. (Deg. C)	-5.8	-1.4	-1.0	9.9	11.1	19.6	20.3	19.4				
Avg. Wind Speed (m/s)	4.2	4.6	4.5	4.0	3.4	3.3	3.1	2.8				
Resultant Wind Direction (Deg)	289	307	288	216	244	219	295	102				
Precipitation (cm)	1.19	17.33	5.45	5.66	11.13	6.13	6.01	3.67				
Direct Normal (MJ/m2.day)	19.1	14.7	20.2	17.2	17.0	15.2	12.6	7.7				
Direct RG630 (MJ/m2.day)	13.5	10.2	13.6	11.5	11.5	10.3	8.8	5.0				
Global Horizontal (MJ/m2.day)	10.6	11.7	17.4	19.9	20.8	23.3	20.3	15.9				
Global RG630 (MJ/m2.day)	7.0	7.5	10.8	12.0	12.4	13.1	11.9	9.3				
Diffuse Horizontal (MJ/m2.day)	2.7	4.2	5.3	8.5	8.8	11.1	11.3	10.8				
Lat. Tilted Global (MJ/m2.day)	17.8	16.0	20.5	19.7	18.3	19.0	17.7	14.8				
Infrared [3-60 u] (MJ/m2.day)	25.5	28.2	28.0	32.0	31.6	34.9	36.2	35.3				
UV [0.30-0.39 u] (MJ/m2.day)	0.48	0.56	0.81	0.98	1.06	1.15	0.98	0.82				
Available Sunshine (%)	66	51	63	56	52	57	47	30				
ETR Horizontal (MJ/m2.day)	19.0	23.8	30.3	36.2	40.0	41.4	40.7	37.7				

(* based on 23 days of data)

Lat 33.65 N Lon 84.42 W

Atlanta Airport (NWS)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Temperature (Deg. C)	4.2	8.2	11.0	19.8	19.8	27.4	27.9	25.4	22.4	15.6		
Heating Degree (C) Days	437	279	228	20	24	0	0	0	9	99		
Cooling Degree (C) Days	0	0	5	69	73	274	300	221	137	20		
Dewpoint Temp. (Deg. C)	-6.1	-1.1	-0.6	10.6	11.1	18.9	20.6	19.4	16.1	9.4		
Avg. Wind Speed (m/s)	5.1	5.2	5.4	4.7	4.6	4.1	4.0	3.8	3.3	4.5		
Resultant Wind Direction (Deg)	300	340	300	230	260	260	300	110	310	50		
Precipitation (cm)	2.13	6.81	9.98	5.23	9.88	6.83	6.96	7.01	13.39	7.65		
Available Sunshine (%)	78	62	74	69	68	76	65	49	77	65		
Sky Cover [sr-ss] (10ths)	4.2	6.8	5.4	6.5	6.5	4.9	5.9	7.6	4.2	5.9		

possesses some unique features, some of which are listed below:

1) Continuous dynamic spectral calibration
2) Continuous wavelength calibration
3) Continuous monitoring with a broad-band silicon detector
4) A full 180° FOV with excellent cosine response

A more complete description of the SSR is given by Bird and Hulstrom [5].

Through use of the minicomputer, plots of the spectra can be generated. There are separate spectra for the visible and the infrared portions. The two separate spectra can be combined to form a single spectrum containing the solar spectrum from 0.3-2.5 μm. The visible portion of the spectrum is degraded in resolution to obtain a resolution comparable to

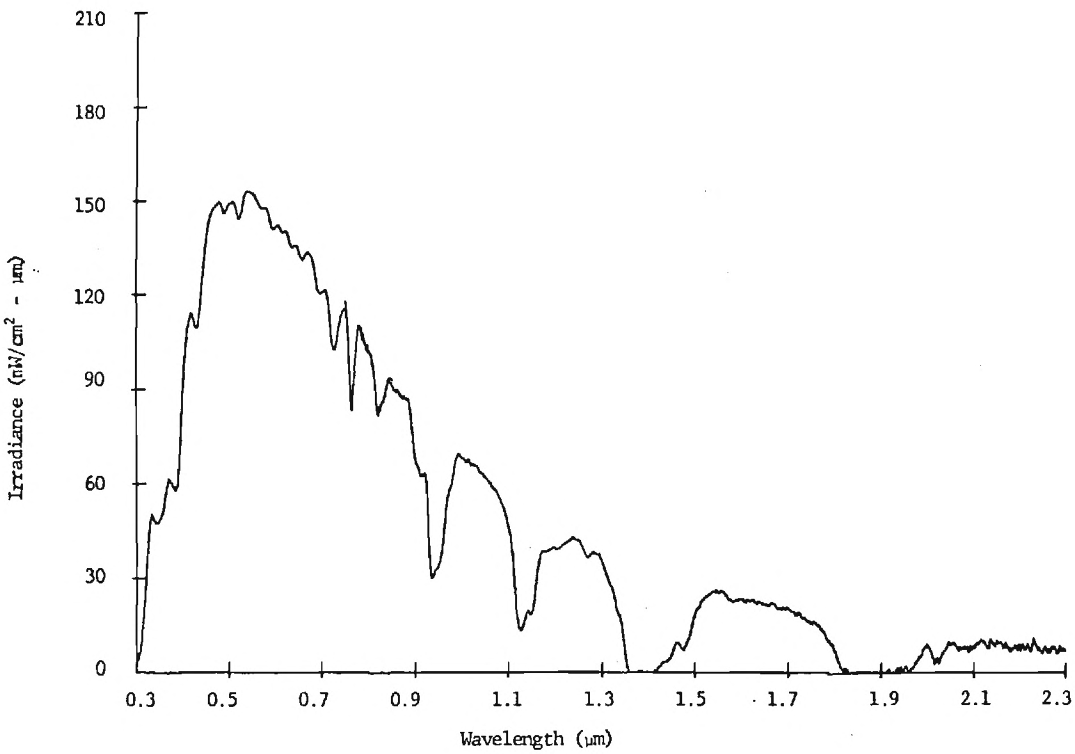


Figure 1. Direct Normal Radiation at Golden, CO, on August 4, 1981 12:24 MST.
Sky conditions: ~40% clouds; solar disc unobscured;
Temp. ~32°C.

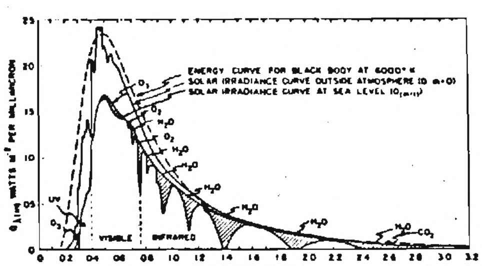


FIGURE 2. SOLAR SPECTRAL ENERGY CURVES SHOWING ABSORPTION DUE TO VARIOUS ATMOSPHERIC CONSTITUENTS.

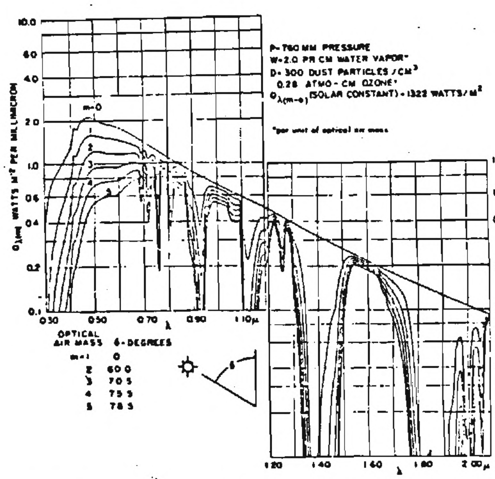


FIGURE 3. SOLAR SPECTRAL IRRADIANCE CURVES AT SEA LEVEL WITH VARYING OPTICAL AIR MASSES.

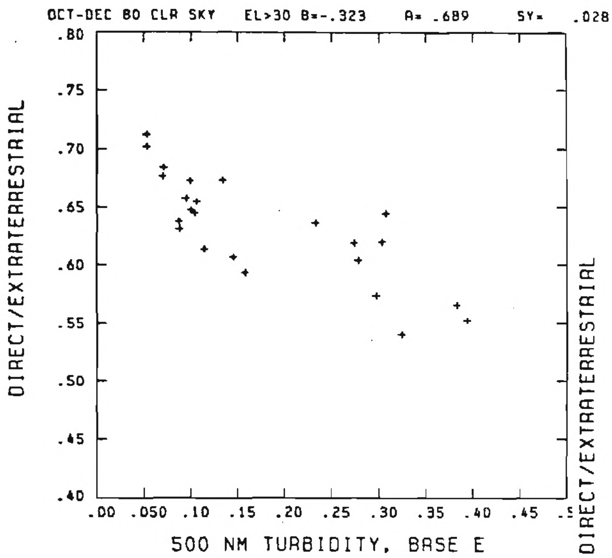


FIGURE 4. DIRECT/EXTRATERRESTRIAL (N/N_0) VERSUS TURBIDITY (τ_{500}) FROM AUTOMATIC SENSOR FOR RELATIVE AIR MASSES < 2. OCTOBER - DECEMBER 1980, CLEAR SKIES ONLY.

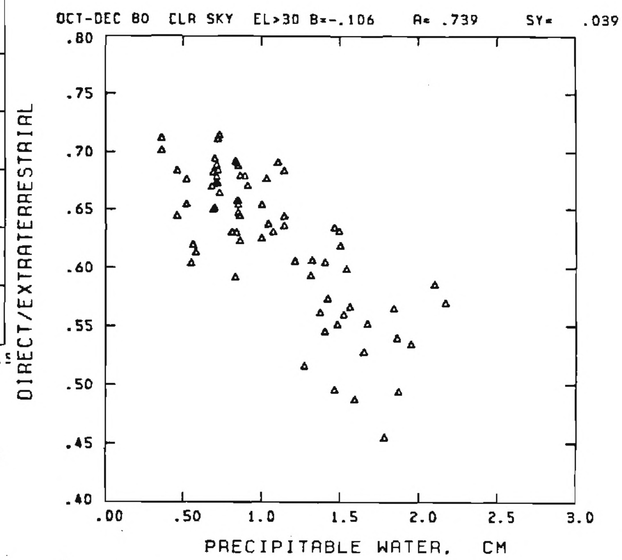


FIGURE 5. DIRECT/EXTRATERRESTRIAL (N/N_0) VERSUS PRECIPITABLE WATER FOR OCTOBER-DECEMBER 1980, CLEAR SKY CONDITIONS.

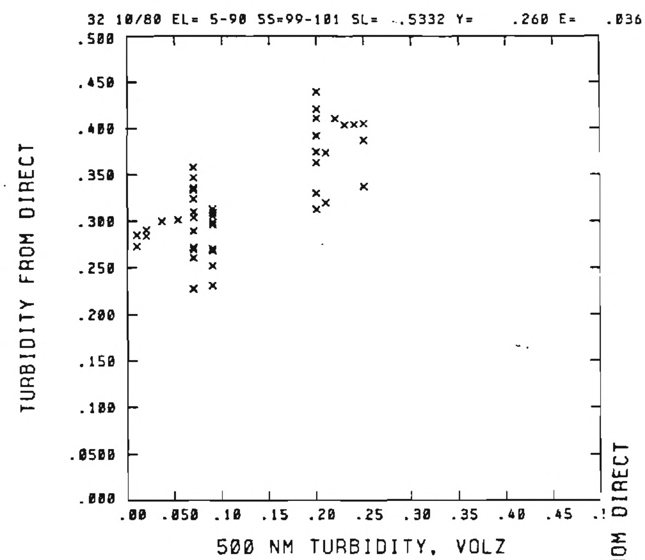


FIGURE 6. BROAD-BAND TURBIDITY (τ) VERSUS 500 nm TURBUDITY (τ_{500}) FROM THE VOLZ PHOTOMETER.

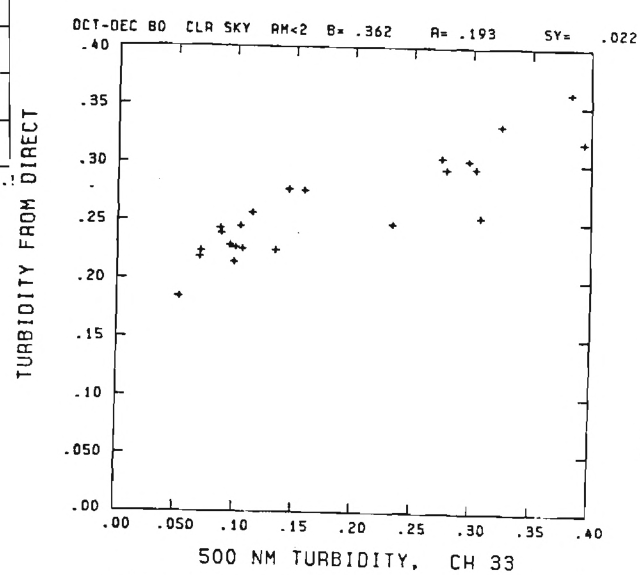


FIGURE 7. BROAD-BAND TURBIDITY (τ) VERSUS 500 nm TURBIDITY (τ_{500}) FROM THE GEORGIA TECH AUTOMATED SUNPHOTOMETER.

that in the infrared region before producing the composite spectrum.

Figure 1 shows a measurement of the direct beam solar irradiance measured at Golden on August 4, 1981 at 12:24 MST (relative air mass 1.08). Figures 2 and 3 (of [6]) show that the observed spectrum agrees well with that expected for typical air mass 1 and average water vapor absorption levels.

Turbidity and Precipitable Water Effects on Direct Beams

Measurements of atmospheric turbidity at a wavelength of 500 nm have been made both with a hand-held Volz photometer and an automatic-tracking sunphotometer designed at Georgia Tech. The 500 nm turbidity is defined as

$$\tau_{500} = [\ell n\ (I(500)/I_0(500) + \tau_R + \tau_0)\ M(p/p_0)]/M \qquad (1)$$

where I(500) is the observed 500 nm relative intensity, $I_0(500)$ is the air m ss-zero 500 nm relative intensity (extrapolated from a "Langley plot" for the instruments being used), τ_R and τ_0 are Rayleigh and ozone turbidity factors ($\tau_R + \tau_0 = 0.155$ for the sensors used) and M is relative air mass (secant zenith angle for zenith angles less than about 80°).

Figures 4 and 5 show the observed variation of direct/extraterrestrial radiation versus turbidity, measured by the automated sensor, or precipitable water, determined from Athens, GA upper-air balloon soundings. Both of these figures are for clear sky conditions only (% sunshine = 100, opaque cloud = 0) and for air masses less than 2.

The direct/extraterrestrial ratio (N/N_0) can be used to define a broadband turbidity (τ) by the relation

$$\tau = \ell n(N/N_0)/M \qquad (2)$$

[note that Rayleigh, ozone, or other effects are not explicitly removed from the calculations of the broad-band turbidity as they are for the 500 nm turbidity in equation (1)].

Figures 6 and 7 show plots of τ versus τ_{500} as determined from the Volz photometer (Figure 6) on the Georgia Tech automated sunphotometer (Figure 7). In Figure 6, the best-fit linear regression is

$$\tau = 0.26 + 0.533\ \tau_{500}\ \text{(Volz)} \qquad (3)$$

with an rms error of regression of 0.036 in τ. Figure 7 yields

$$\tau = 0.19 + 0.362\ \tau_{500}\ \text{(auto)} \qquad (4)$$

with an rms error of 0.022.

A better correspondence is found between the ratio diffuse/direct radiation and broad-band turbidity, as shown in Figure 8, which indicates

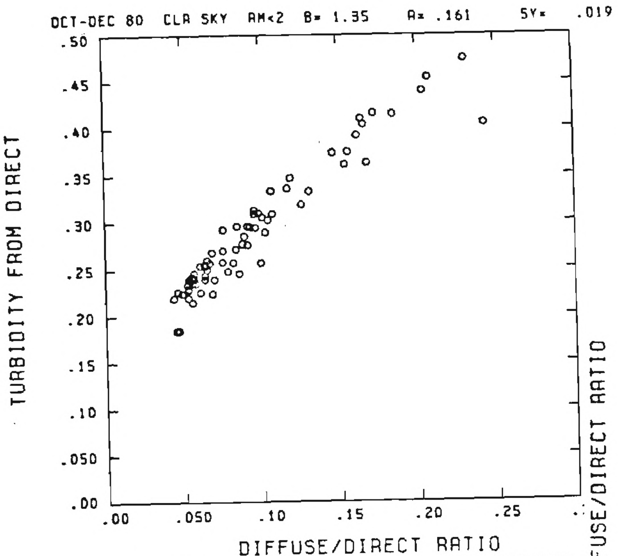


FIGURE 8. BROAD-BAND TURBIDITY (τ) VERSUS RATIO DIFFUSE/DIRECT.

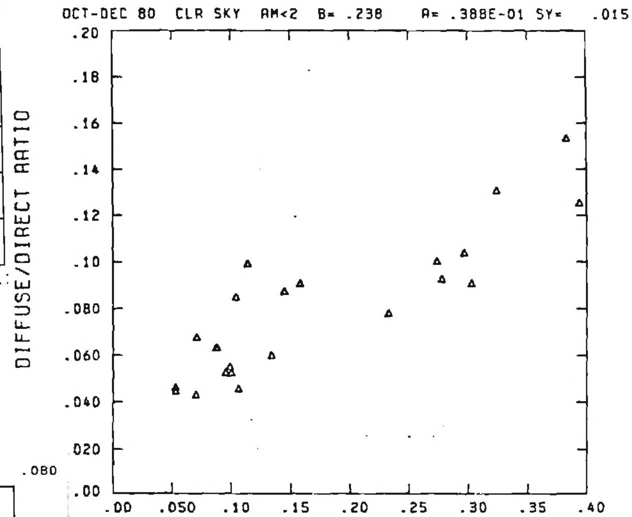


FIGURE 9. DIFFUSE/DIRECT RATIO VERSUS 500 nm TURBIDITY FROM THE AUTOMATED SENSOR.

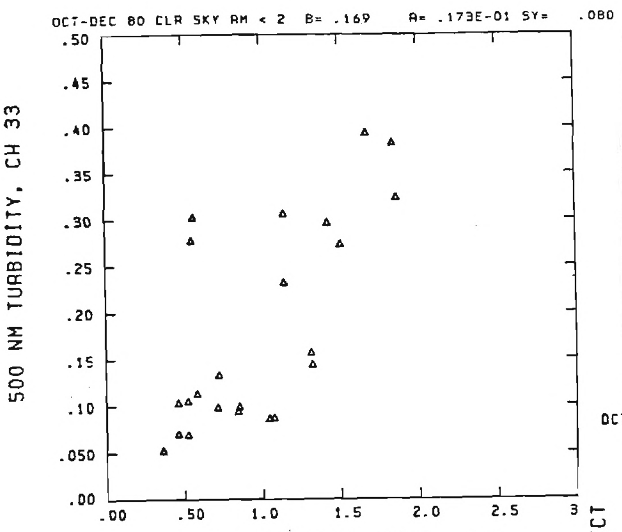


FIGURE 10. 500 nm TURBIDITY VERSUS PRECIPITABLE WATER.

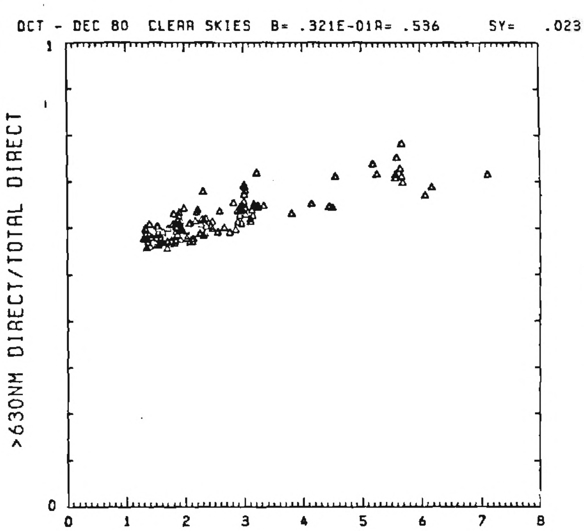


FIGURE 11. DIRECT BEAM SPECTRAL RATIO OF (RG630 DIRECT)/(TOTAL DIRECT) [N (>630 nm)/N] VERSUS AIR MASS OCTOBER-DECEMBER 1980, CLEAR SKY CONDITIONS.

$$\tau = 0.16 + 1.35\ (D/N) \tag{5}$$

where D is the diffuse (all-sky) radiation on a horizontal surface and N is the direct normal radiation. The regression (5) has an rms error of only 0.019 in τ. Dependence of the diffuse/direct ratio on τ_{500} is illustrated in Figure 9.

The effect of turbidity and percipitable water on the direct beam, as illistrated in Figures 4 and 5, are not entirely independent. Figure 10 indicates that the 500 nm turbidity has a distinct direct trend with precipitable water with a "best-fit" regression of

$$\tau_{500} = 0.02 + 0.169\ (PW) \tag{6}$$

with an rms regression error of 0.08 in τ_{500}. PW is precipitable water in cm.

Effects of Turbidity and Precipitable Water on Spectral Ratios

As shown in Figures 2 and 3, essentially all of the water vapor absorption occurs at wavelengths above 0.63 μ (630 nm). Thus, the direct spectral radiation (N>630) measured through a 630 nm filter

$$N(>630) = \int_{630}^{\infty} N(\lambda)d\lambda \tag{7}$$

should be a good measure of precipitable water attenuation effects. The direct beam also reddens with increasing air mass, i.e., N(>630)/N gets larger. Hence, it seems reasonable that N(>630)/N should show an opposite effect (i.e., decrease) with increased water vapor at a fixed air mass. Figure 11 shows the expected reddening (increasing N(>630)/N) with air mass for clear sky conditions (100% sunshine, 0 opaque cloud cover). However, Figure 12 shows no significant effect of N(>630)/N with precipitable water amounts for the limited air mass range $M<2$ for clear skies. Figure 13 does show a slight (non-significant) downward trend of the spectral ratio with 500 nm turbidity.

Diffuse With Tracking Disc and Shadow-Band

The primary instrument at Georgia Tech for measuring diffuse radiation is an Eppley PSP with an Eppley-designed automatic tracking disc. The more common technique is to use a non-tracking shadow-band, which blocks out both the direct beam, and also part of the diffuse radiation being observed. The shadow-band measurement requires a correction factor, shown as the solid line in Figure 14 for the dimensions of the Eppley shadow-band and the latitude of Georgia Tech, as derived by Drummond [8]. The observed correction necessary to obtain agreement between the tracking-disc and the shadow-band diffuse measurements is shown as the dotted curve in Figure 14. Except for July, good agreement is found between the observed shadow-band correction and that computed by the Drummond technique. Other studies of shadow-band corrections necessary have also been reported recently by Painter [9].

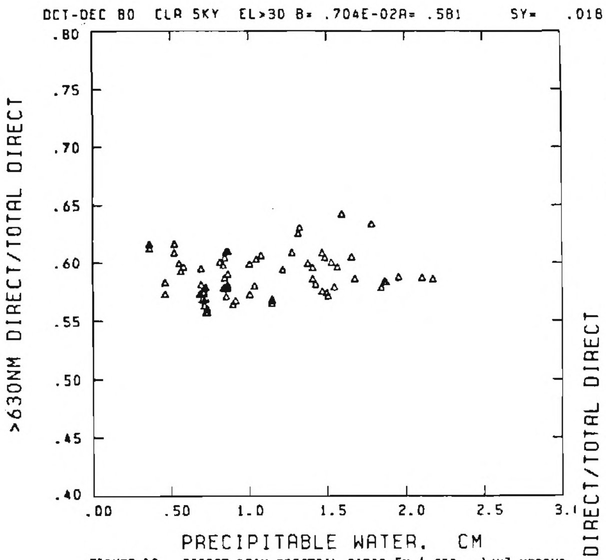


FIGURE 12. DIRECT BEAM SPECTRAL RATIO [N (>630 nm)/N] VERSUS PRECIPITABLE WATER. AIR MASS < 2, CLEAR SKIES.

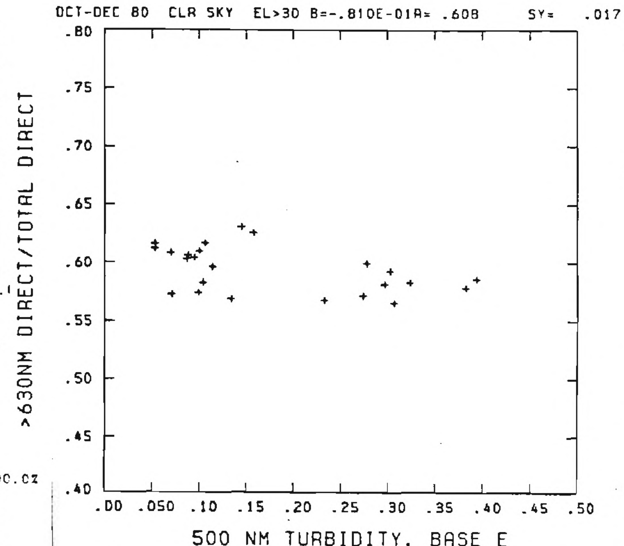
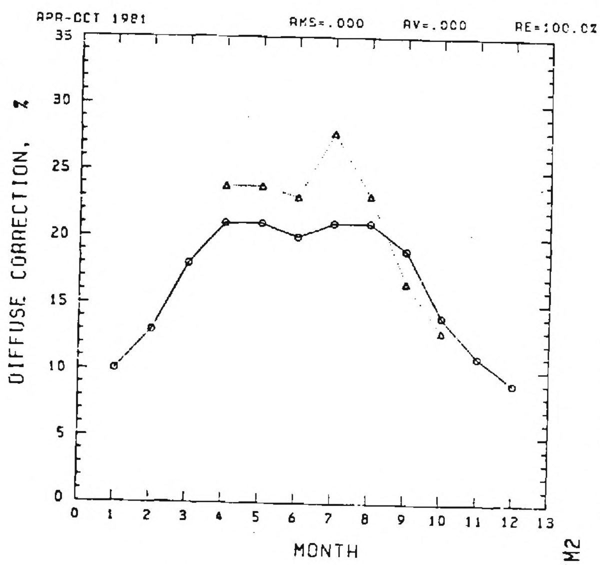


FIGURE 13. DIRECT BEAM SPECTRAL RATIO [N (>630 nm)/N] VERSUS 500 nm TURBIDITY. OCTOBER-DECEMBER 1980, CLEAR SKIES, AIR MASS < 2.



SOLID LINE = DRUMMOND CORRECTION
DOTTED LINE = OBSERVED CORRECTION REQUIRED

FIGURE 14. COMPARISON OF OBSERVED DIFFUSE SHADOW-BAND CORRECTIONS VERSUS ESTABLISHED SHADOW-BAND CORRECTION BY DRUMMOND.

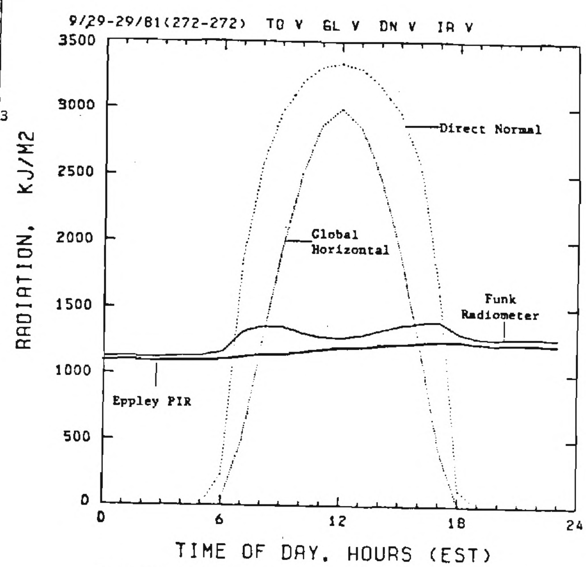


FIGURE 15. INFRARED RADIATION FOR EPPLEY PIR, FUNK RADIOMETER, AND THE DIRECT NORMAL AND GLOBAL HORIZONTAL RADIATION ON A CLEAR DAY (9/29/81).

Infrared Measurement Errors

In an earlier report [7] it was noted that the Funk-type radiometer used at Georgia Tech is observed to have several percent difference in response to short-wave (<3 μ) and long wave (>3 μ) radiation. Analysis of corresponding measurements with the Funk radiometer and an Eppley (PIR) pyrgeometer on clear days shows that the Funk radiometer has a non-linear response, as shown in Figure 15. The Funk radiometer responds with more sensitivity to short-wave radiation at low sun angles than at high sun angles. This behavior is illustrated by the plot of the Eppley PIR (heavy solid line) in Figure 14, compared with the IR computed from total-versus-short-wave for the Funk radiometer (light solid line). The erroneous response of the Funk instrument seems to follow more closely the direct normal radiation than the global horizontal radiation. Thus the non-linear short-wave response may be due to internal reflection within the polyethylene dome used in the Funk radiometer.

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